APPENDIX A

Priority and Highest Priority Water Quality Condition Selection Methodology

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APPENDIX A Priority and Highest Priority Water Quality Condition Selection Methodology

The methodology to select the priority and highest priority water quality conditions follows four steps.

Step 1: Determine Receiving Water Conditions (Permit B.2.a). The goal of the receiving water assessment is to determine the receiving water conditions in the watershed. Some receiving water conditions may be selected as priority water quality conditions if there is sufficient data showing that the MS4 is causing and contributing to the receiving water condition or if it is suspected that the MS4 may be causing and contributing but there is a gap in the data.

a. Information and data to evaluate receiving waters conditions includes:
   i. TMDLs;
   ii. 303(d) listings to determine impaired beneficial uses;
   iii. Sources that are provided as part of the 303(d) listing. (This is important if the 303(d) listing has called out the MS4 as a source);
   iv. RW limits for appropriate segments;
   v. Historic and current data from the LTEA and WURMP. (Associate a NPDES monitoring location with each watershed when available. The priorities listed by these documents exceed water quality benchmarks.); and
   vi. 3rd party data submitted in response to public data call.
b. Determine a receiving water condition based on the following criteria:
   i. TMDLs in the watershed applied upstream where appropriate;
   ii. All 303(d) listings;
   iii. All additional receiving water conditions indentified by reviewing historic and current monitoring data; and
   iv. 3rd party data submitted in response to public data call.

Step 2: Determine Potential Receiving Water Impacts from MS4 Discharges (Permit B.2.b). Review MS4 Monitoring Data to determine potential receiving water impacts associated with MS4 discharges by assessing the following:

a. Outfall monitoring data provided in the WURMP and LTEA. (It is important to note that often only one MS4 wet weather outfall location is associated with each NPDES monitoring location, meaning that the analysis is done at the subwatershed level and not in the receiving water);
b. WQBELs where appropriate;
c. The 303(d) listing identifies the MS4 as a source; and
d. 3rd party data submitted in response to public data call.

Step 3: Determine Priority Water Quality Conditions (Permit B.2.c.(1)). The goal of this step is to select the priority water quality conditions by analyzing the receiving water conditions based on the potential for the MS4 to cause and contribute to the condition. Priority water quality conditions may be identified based on the following criteria:

a. MS4 subwatershed outfall data compared to the receiving water condition. If the subwatershed level outfall data shows that MS4 is causing and contributing to the receiving water condition then it may be considered a priority water quality condition;
b. If there is no outfall monitoring data associated with the receiving water condition, the 303(d) listing will be referenced to determine if the MS4 is included as a source. If the MS4 is listed as a source, this receiving water condition may be considered a priority water quality condition with a data gap; and
c. Consider 3rd party input submitted in response to public data call.

Step 4: Determine Highest Priority Water Quality Condition(s) (Permit B.2.c.(2)). The MS4 Permit requires the Copermittees to identify the highest priority water quality conditions to be addressed by the Water Quality Improvement Plan, and provide a rationale for selecting a subset of the priority water quality conditions identified in Step 3. Because the MS4 Permit requires the development and identification of numeric goals, strategies, and schedules for the highest priority water quality conditions, a scientifically-based screening analysis of priority water quality conditions was applied. Conditions already subject to an approved TMDL, ASBS or other water quality regulation will be elevated to highest priority water quality condition.

The Responsible Agencies will identify priority water quality conditions not subject to an approved water quality regulation as a highest priority based on the following factors:

a. The supporting data set is sufficient to adequately characterize the degree to which the priority water quality condition changes seasonally, and over geographic area, to support its consideration as a highest priority water quality condition.
b. Storm water/ non-storm water runoff is a predominant source for the priority water quality condition.
c. The priority water quality condition is controllable by the Responsible Agencies.
d. The priority water quality condition would not be addressed by strategies identified for other highest priority water quality conditions in this Water Quality Improvement Plan.

APPENDIX B

San Dieguito River WMA Maps

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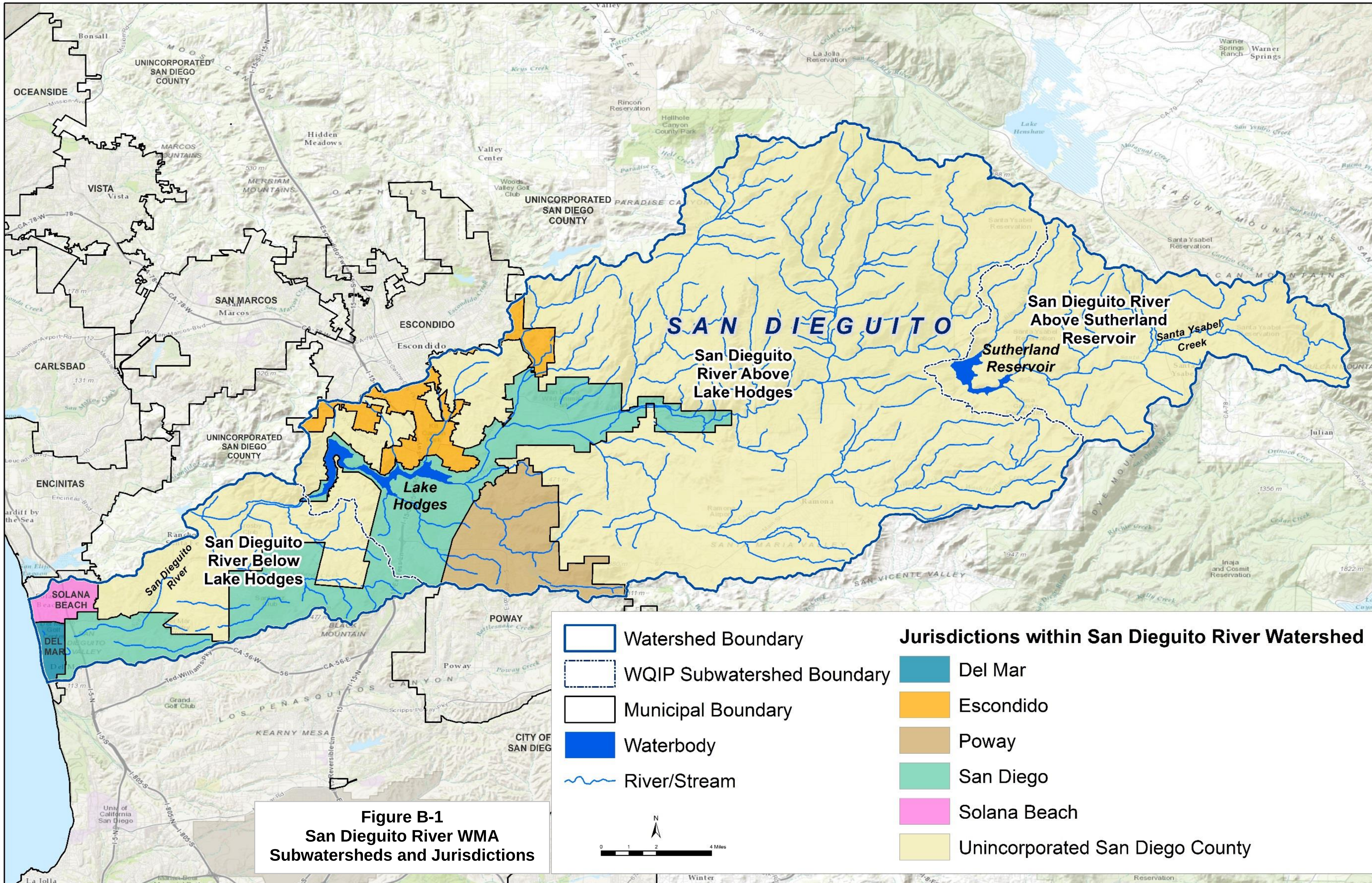

Figure B-1
San Dieguito River WMA
Subwatersheds and Jurisdictions

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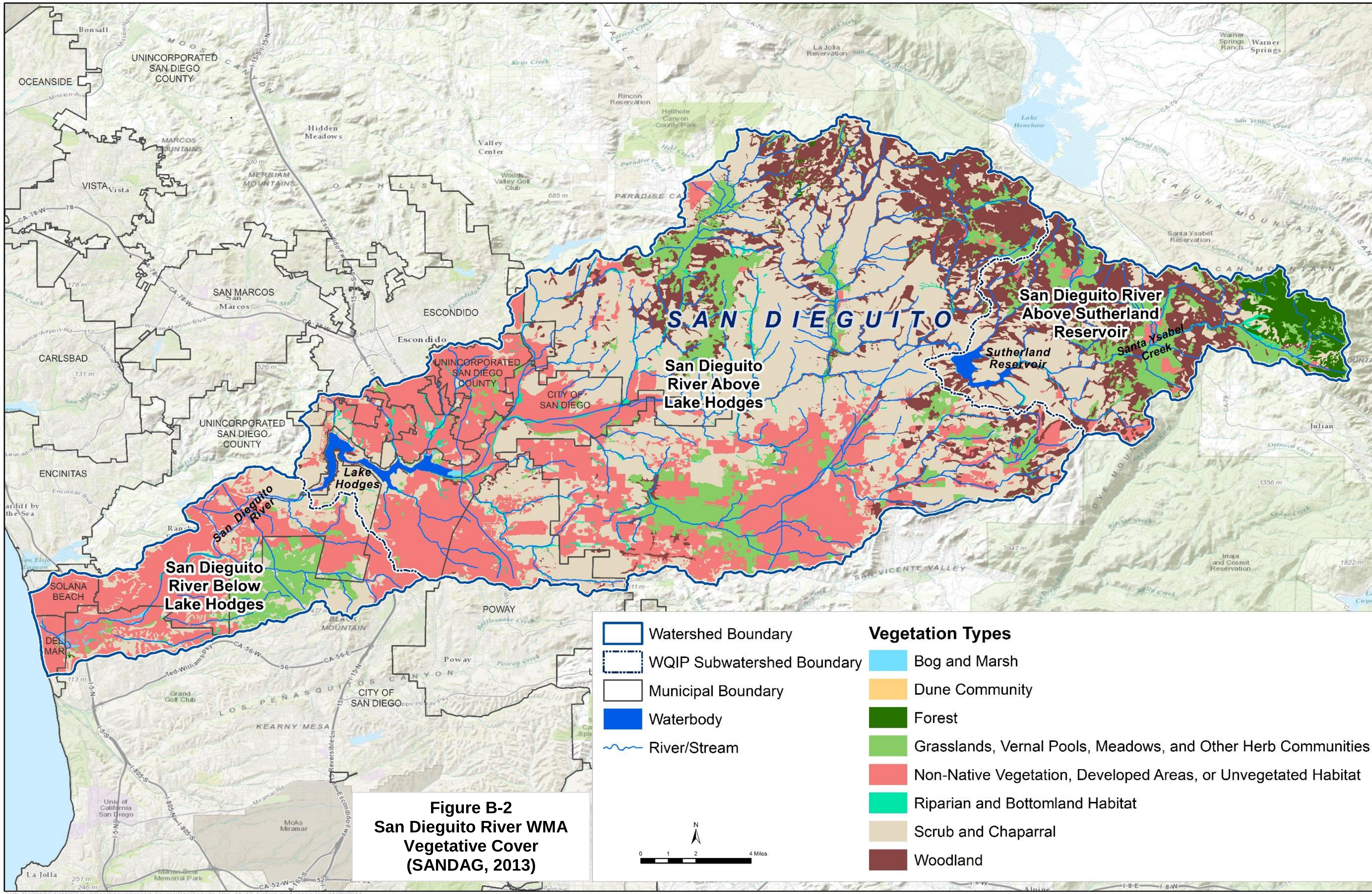

Figure B-2
San Dieguito River WMA
Vegetative Cover
(SANDAG, 2013)

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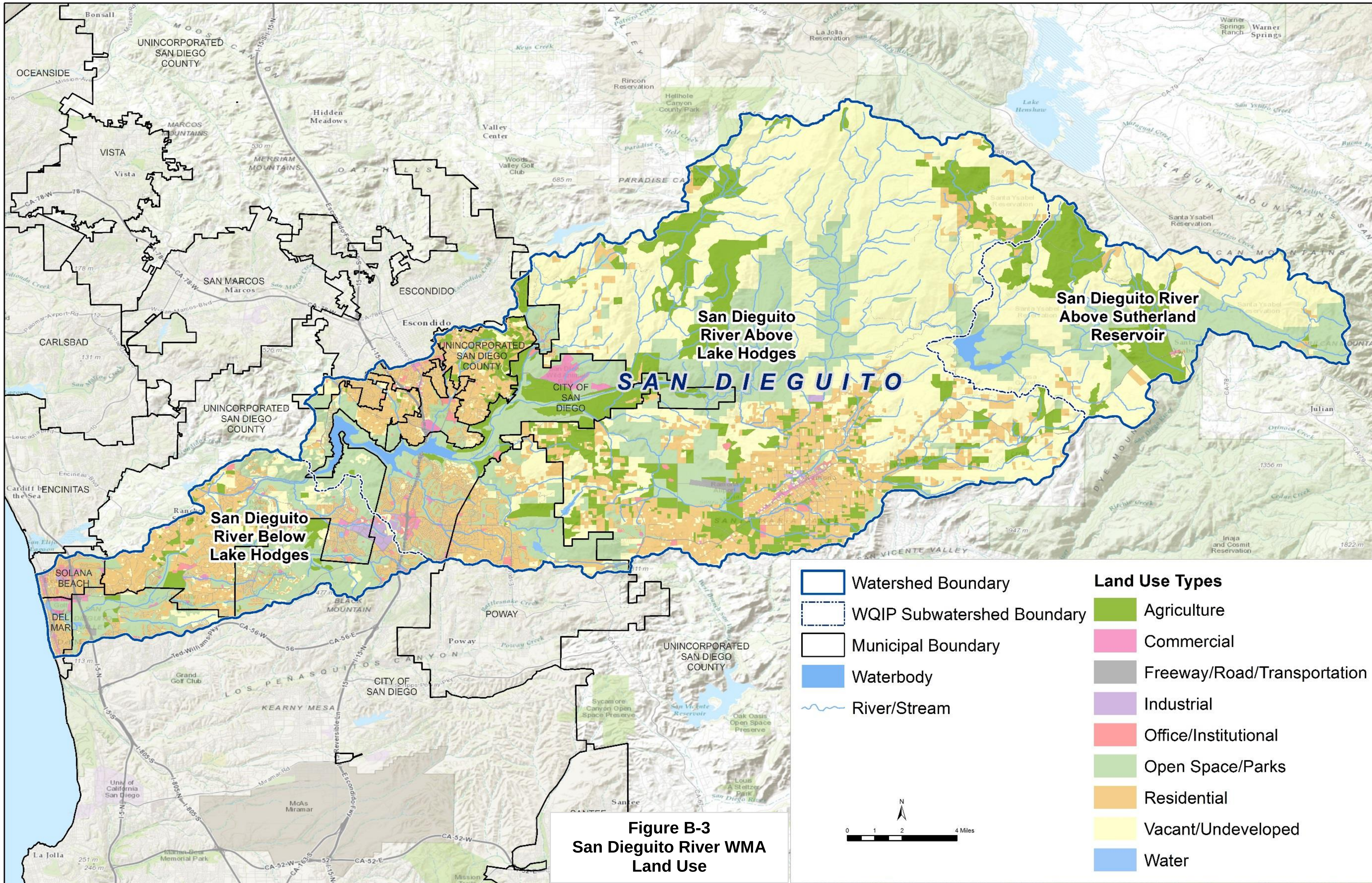

Figure B-3
San Dieguito River WMA
Land Use

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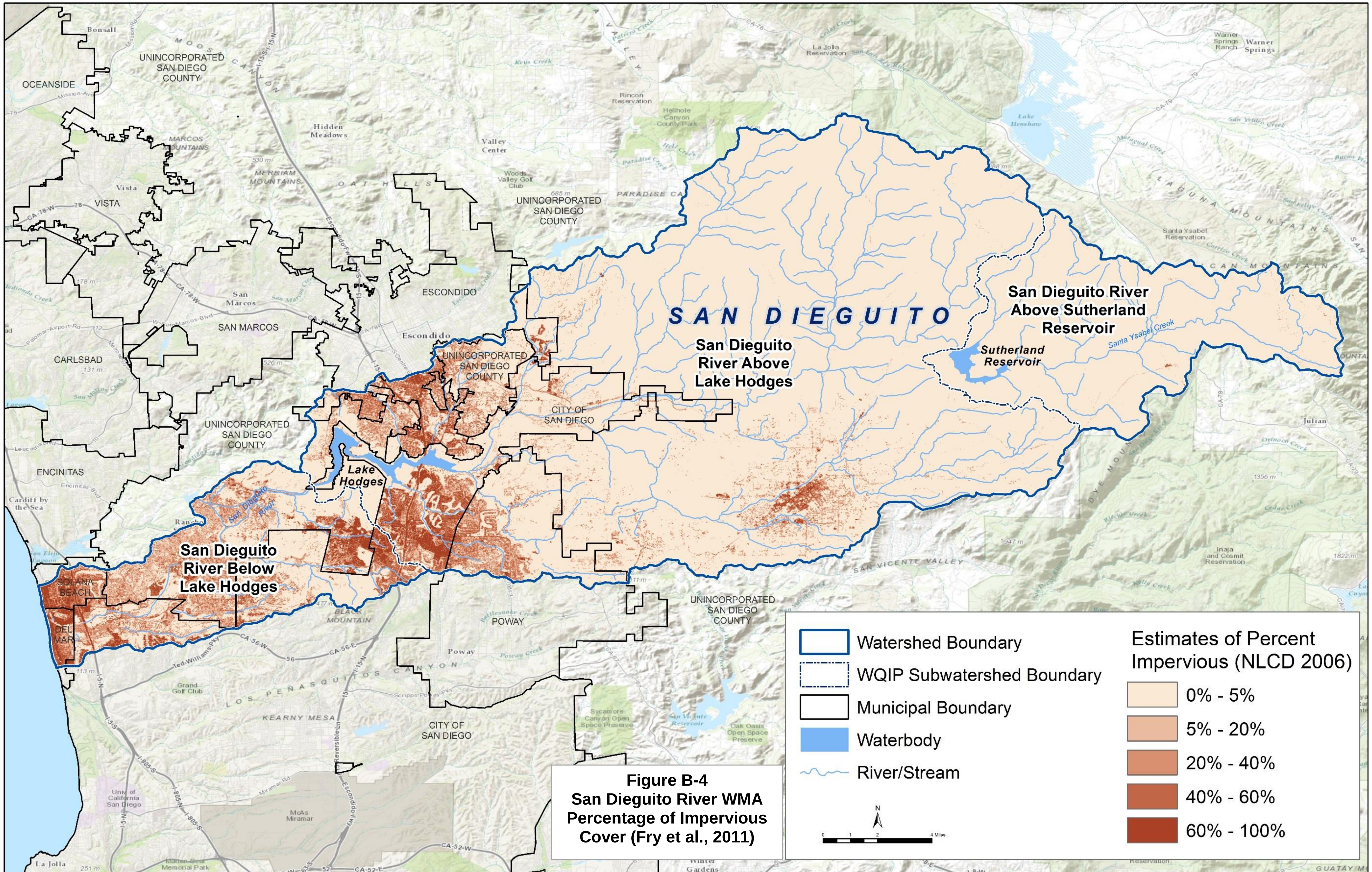

Figure B-4
San Dieguito River WMA Percentage of Impervious Cover (Fry et al., 2011)

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APPENDIX C

Beneficial Uses of 303(d) Listed Waterbodies in the San Dieguito River WMA

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Table C-1 presents the beneficial use designations of the 303(d) listed waterbodies in the San Dieguito River WMA. Beneficial uses specifically identified as impaired by the 2010 303(d) list are shaded blue. This table does not present waterbodies that were not identified as impaired on the 303(d) list. Approximately 97% of the waterbodies in the San Dieguito River WMA are not impaired or have not been assessed. Of those waterbodies that are listed as having impairments, most beneficial uses are attained.

Table C-1
Beneficial Uses of the 2010 303(d) Listed Waterbodies in the San Dieguito River WMA

303(d) Listed Waterbody Name	Beneficial Use																			
	IND	NAV	COMM	MUN	AGR	IND	PROC	GWR	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	MAR	AQUA	MIGR	SPWN	SHELL
Santa Ysabel Creek (905.53 and 905.54)				●	●	●	●		●	●		● (impaired)	●	●					●	
Sutherland Reservoir (905.53)				● (impaired)	●	●	●		●	●		● (impaired)	●	●	●					
Cloverdale Creek (905.32)				●	● (impaired)	●	●		○	●		● (impaired)		●	●					
Kit Carson Creek (905.21)				● (impaired)	●	●	●	○	●	●		●		●	●					
Green Valley Creek (905.21 and 905.22)				● (impaired)	●	●	●	○	●	●		●		●						
Felicita Creek (905.23)				● (impaired)	●	●	●	○	●	●		●		●						
Lake Hodges (905.21)				● (impaired)	●	●	●		●	● (impaired)		●	●	●	●					
San Dieguito River (905.11 and 905.21)				●	●	●	●		● (impaired)	●	●	● (impaired)	●	●	●				●	
Pacific Ocean Shoreline at San Dieguito Lagoon Mouth (905.11)	●	●	●						●	●	●			●	●	●	●	●	●	● (impaired)

(impaired) = shaded blue: Beneficial use is impaired based on the 2010 303(d) list
○ Potential beneficial use
● Existing beneficial use

The beneficial uses that are impaired in 303(d)-listed waterbodies the San Dieguito River WMA are defined in the Basin Plan as follows:

- **AGR (Agricultural Supply)** includes uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- **MUN (Municipal and Domestic Supply)** includes uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply.

- **REC-1 (Contact Water Recreation)** includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs.
- **REC-2 (Non-Contact Water Recreation)** includes the uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
- **SHELL (Shellfish Harvesting)** includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes.
- **WARM (Warm Freshwater Habitat)** includes uses of water that support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

The beneficial uses in the San Dieguito WMA which are not impaired are defined in the Basin Plan as follows:

- **AQUA (Aquaculture)** includes the uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
- **BIOL** (**Preservation of Biological Habitats of Special Significance)** includes uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.
- **COLD (Cold Freshwater Habitat)** includes uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.
- **COMM** (**Commercial and Sport Fishing)** includes the uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.
- **GWR** (**Ground Water Recharge)** includes uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.
- **IND** (**Industrial Service Supply)** includes uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining,

cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

- **MAR (Marine Habitat)** includes uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

- **MIGR** (**Migration of Aquatic Organisms)** includes uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.

- **NAV (Navigation)** includes uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

- **PROC (Industrial Process Supply)** includes uses of water for industrial activities that depend primarily on water quality.

- **RARE (Rare, Threatened, or Endangered Species)** includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

- **SPWN (Spawning, Reproduction, and/or Early Development)** includes uses of water that support high quality habitats suitable for reproduction, early development and sustenance of marine fish and/or cold freshwater fish.

- **WILD (Wildlife Habitat)** includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

APPENDIX D

Additional Data Sources

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APPENDIX D.1

Primary and Secondary Data Sources

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Primary and Secondary Data Sources

Primary References

2011 Long-Term Effectiveness Assessment. San Diego County Municipal Copermittees Urban Runoff Management Programs. Final Report
2011-2012 San Diego County Copermittee Receiving Waters and Urban Runoff Monitoring Report
2010-2011 San Diego County Copermittee Receiving Waters and Urban Runoff Monitoring Report
2008 City of Del Mar Jurisdictional Urban Runoff Management Plan (JURMP) (Including FY10 Annual Report)
City of Solana Beach JURMP (FY12 Annual Report)
2008 City of Escondido JURMP (Including FY12 Annual Report)
2008 City of Poway JURMP (Including FY12 Annual Report)
2008 City of San Diego JURMP (Including FY11 and FY12 Annual Report)
2008 County of San Diego JURMP (Including FY10 and FY11 Annual Report)
San Dieguito River Watershed Urban Runoff Management Program (WURMP) (Including FY11 and FY12 Annual Report)
San Dieguito CLRP Phase I

Additional References

Bradshaw, J.S. and P.J. Mudie. 1972. Some Aspects of Pollution in San Diego County Lagoons. Calif. Mar. Res. Comm., CalCOFI Rept., 16: 84-94, 1972.
California Coastal Commission. 2005. Regular Calendar Staff Report and Recommendation. Application No. 6-04-88. Application from Southern California Edison and San Dieguito River Park Joint Powers Authority for implementation of the San Dieguito Wetland Restoration Plan and construction of a portion of the Coast to Crest Trail. Available at http://www.coastal.ca.gov/energy/songs/W8f-10-2005.pdf. Accessed on September 22, 2011.
California Department of Resources Recycling and Recovery (CalRecycle). 2013. Solid Waste Information System. http://www.calrecycle.ca.gov/SWFacilities/Directory/Search/. Last visited October 2013.
City of Del Mar, 1988. Landscape Development Guidelines. Available at:
City of Del Mar, 2010. Jurisdictional Urban Runoff Management Program Annual Report 2009-2010. Available at: http://www.delmar.ca.us/Government/dept/Documents/FY2009%20-%202010%20JURMP%20Annual%20Report%20-%20Final.pdf. Accessed on September 30, 2011.
City of Del Mar, 2011. Standard Urban Storm Water Mitigation Plan. Available at: http://www.delmar.ca.us/News/Pages/2010StandardUrbanStormwaterMitigationPlan(SUSMP).aspx.
City of Del Mar. 1979. San Dieguito Lagoon Resource Enhancement Program
City of Escondido. 2008. Jurisdictional Urban Runoff Management Plan. Available at: http://www.escondido.org/Data/Sites/1/media/pdfs/Utilities/JURMP.pdf
City of San Diego, 2004. Draft Watershed Resources to be Protected and Enhanced Report. Available at: http://www.projectcleanwater.org/pdf/pen/pen-ws-resources.pdf.

City of San Diego, 2006. San Dieguito Watershed Management Plan. Prepared by Weston Solutions. September. San Diego, CA.
City of San Diego, 2007. Strategic Plan for Watershed Activity Implementation. November. San Diego, CA.
City of San Diego. 2009. Tecolote Creek Microbial Source Tracking Study. Phase II. Final. June 30. San Diego, CA.
City of San Diego, 2010. City of San Diego Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment. Final Report
City of San Diego, 2011. City of San Diego San Dieguito Bacteria and Nutrients TMDL-Watershed Characterization Study. June. San Diego, CA.
City of San Diego, 2011. Enterococcal Sources and Growth Related to Two Storm Drains in San Diego County. Draft Final Report.
City of San Diego, 2011. Long Term Effectiveness Assessment Water Quality Report. Available at: http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=185:2011-ltea-water-quality-report&catid=16.
City of San Diego 2012a. Tecolote Creek Comprehensive Load Reduction Plan. June. San Diego, CA.
City of San Diego, 2012. San Dieguito Watershed Characterization Study. Technical Memorandum. Prepared by AMEC Environment & Infrastructure, Inc.
City of San Diego, 2012. Dewatering Discharge and Groundwater Seepage. Technical Memorandum. Prepared by AMEC Environment & Infrastructure, Inc.
City of San Diego. 2010. Watershed Sanitary Survey. Available at: https://www.sandiego.gov/water/quality/environment/sanitarysurvey.shtml
City of Solana Beach and URS Corporation. 2002. City of Solana Beach Jurisdictional Urban Runoff Management Runoff Program. February 12, 2002.
Clean Water Act of 1972. 33 U.S. Code §1251 et seq.
Conservation Biology Institute. 2007. Baseline Conditions Report for Ramona Grasslands Preserve San Diego County. County of San Diego.
County of Los Angeles. 2010. Multi-pollutant TMDL Implementation Plan for the Unincorporated County Area of Los Angeles River Watershed. Los Angeles, CA.
County of San Diego, 2007. Floodplain Management Plan, County of San Diego, CA. Available at: http://www.co.san-diego.ca.us/dpw/floodcontrol/floodcontrolpdf/floodplainmanagementplan.pdf.
County of San Diego, 2011. Hydromodification Management Plan. Final. Prepared by Brown & Caldwell for the County of San Diego, CA. Available at: http://www.projectcleanwater.org/images/stories/Docs/LDS/HMP/0311_SD_HMP_wAppendices.pdf
County of San Diego, 2012. 2010-11 Urban Runoff Monitoring Annual Report. January 2012. Available at: http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=191:2010-11-urban-runoff-monitoring-annual-report&catid=17&Itemid=91
Elwany, 2011. Characteristics, Restoration and Enhancement of Southern California Lagoons. J. of Coastal Research. Vol. 59: 246-255.

Environment Now. 2002. Watershed Management Plan Characterization Report for Coastal Southern California. Southern California Wetlands Recovery Project. SWRCB Agreement Number 01-156-259-0. Available at http://portal.countyofventura.org/portal/page/portal/ceo/divisions/ira/WC/Library/IRWM_Planning/watershedmagt_plan_character.pdf. Accessed on September 29, 2011.
Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J. 2011. Completion of the 2006 National Land Cover Database (NLCD) for the Conterminous United States, PE&RS, Vol. 77(9):858-864.
Fuscoe Engineering, Inc.. 2009. Master Plan Update Del Mar Fairgrounds, Hydrology and Water Quality Report. City of Del Mar. LSA Associates, Inc. February 9, 2009.
Gergorio, D. and S.L. Moore. Discharge into state water quality protection areas in southern California. Available at: http://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2003_04AnnualReport/ar23-moore_286-290.pdf
Kennison, R., K. Kamer, P. Fong. 2004. Nutrient dynamics and macroalgal blooms: a comparison of five southern California estuaries. Southern California Coastal Research Project. Available at: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/416_nutrient_dynamics.pdf
National Resources Conservation Service (NRCS). 1999. CalWater, California Watershed Dataset. Available at http://catalog.data.gov/dataset/calwater-2-233fac
Raphael D. Mazor and Ken Schiff. 2007. Surface Water Ambient Monitoring Program (SWAMP) Report on the San Dieguito Hydrologic Unit. Available at: http://www.swrcb.ca.gov/rwqcb9/water_issues/programs/swamp/docs/905sandieguitorpt.pdf.
San Diego Association of Governments (SANDAG). 2009. 2009 Land Use GIS Data. Available at http://www.sandag.org/resources/maps_and_gis/gis_downloads/land.asp
San Diego Association of Governments (SANDAG). 2013. 2013 Vegetation Information Maintained by San Diego County Department of Planning and Land use. Available at http://www.sandag.org/index.asp?subclassid=100&fuseaction=home.subclasshome
San Diego Bay Co-Permittees, 2011. San Diego Bay Watershed Urban Runoff Management Program 2009-2010 Annual Report.
San Diego Bay Watersheds. Aluminum. Accessed April 30, 2013. http://www.sdbay.sdsu.edu/glossary/index.php
San Diego Citizen Watershed Monitoring Consortium. 2011. World Water Monitoring Data. 2006-2010.
San Diego County Municipal Copermittees. 2011. Report of Waste Discharge Application for Renewal of NPDES Municipal Storm Water Permit for San Diego County. June 24. San Diego, CA.
San Diego Regional Water Quality Control Board (Regional Board). 1994. Water Quality Control Plan for the San Diego Region (9). September. San Diego, CA
San Diego Regional Water Quality Control Board (Regional Board), 2007. Revised Conditional Waivers of Waste Discharge Requirements for Specific Types of Discharge Within the San Diego Region. Resolution No. R9-2007-0104.
San Diego Regional Water Quality Control Board (Regional Board). 2009. Administrative Civil Liability Order No. R9-2009-0172. Lake Hodges Sewage Spill.
San Diego Regional Water Quality Control Board (Regional Board). 2010. Chatham Brothers Barrel Yard Site Spill.

San Diego Regional Water Quality Control Board (Regional Board). 2010. Revised TMDL for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek). Resolution No. R9-2010-0001. Approved February 10, 2010. http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/bacteria.shtml.
San Diego Regional Water Quality Control Board (Regional Board). 2013. Order Number R9-2013-0001, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer System (MS4) Draining the Watersheds Within the San Diego Region.
San Dieguito River Park Staff, KTU+A Landscape Architects, Dudek & Associates, Kimley Horn & Associates. 2000. Park Master Plan for the Coastal Area of the San Dieguito River Valley Regional Open Space Park. San Dieguito River Park Joint Powers Authority Board of Directors.
Schiff, K., B. luk, D. Gregorio, S. Gruber. 2011. Southern California Bight 2008 Regional Monitoring Program: II Areas of Special Biological Significance. Southern California Coastal Research Project. Available at: http://www.sccwrp.org/Homepage/RecentPublications.aspx.
Schoen, M.E., Ashbolt, N.J. 2010. Assessing Pathogen Risk to Swimmers at Non-Sewage Impacted Recreational Beaches. Environmental Science and Technology 44(7): 2286-2291.
Soller, J.A., Schoen, M.E., Bartrand, T., Ravenscroft, J., Wade, T.J. 2010b. Estimated Human Health Risks from Exposure to Recreational Waters Impacted by Human and Non-Human Sources of Fecal Contamination. Water Research 44(16): 4674-4691.
Southern California Coastal Water Research Project (SCCWRP). 2010. Project Group: Reference Conditions Accessed February 8, 2014. http://www.sccwrp.org/researchareas/Stormwater/RunoffCharacterization/ReferenceConditions.aspx
Southern California Coastal Water Research Project (SCCWRP). 2012. San Diego County Enterococcus Regrowth Study, Final Report. Accessed February 5, 2014. http://www.projectcleanwater.org/images/stories/Docs/MON/final%20work%20products/Bacteria_Regrowth_Study.pdf
Southern California Edison Company. 2005. San Dieguito Wetlands Restoration Project Final Restoration Plan. California Coastal Commission. November 2005.
Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program 2008 Report
State of California 22nd District Agricultural Association (22nd DAA), 2012. Storm Water Management Plan Del Mar Fairgrounds/Horse Park. Prepared by Fuscoe Engineering on behalf of 22nd DAA. March, 2012.
State Water Resources Control Board (State Board), 1997. Order Number 97-03-DWQ, National Pollutant Discharge Elimination System (NPDES) General Permit Waste Discharges Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities.
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Felicita Creek 303(d) listing. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01612.shtml
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Green Valley Creek 303(d) listing. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01611.shtml

State Water Resources Control Board (State Board). 2008. Draft 2008 California 303(d)/305(b) Integrated Report Supporting Information. Fact Sheets.
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Cloverdale Creek 303(d) listing. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01613.shtml
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Kit Carson Creek. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01609.shtml
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. San Dieguito River 303(d) listing. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/02006.shtml
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Sutherland Reserve. 303(d) listing. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00500.shtml
State Water Resources Control Board (State Board). 2010. Final California 2010 Integrated Report (303(d) List/305(b) Report). Supporting Information. Lake Hodges 303(d) listings. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/00499.shtml
State Water Resources Control Board (State Board). 2011a. Storm Water Multiple Application and Report Tracking System (SMARTS). Accessed November 4, 2011. https://smarts.waterboards.ca.gov/smarts/faces/SwSmartsLogin.jsp.
State Water Resources Control Board (State Board). 2011b. *NPDES Permits (including Storm Water)*. Excel spreadsheet download. Accessed December 6, 2011. http://www.waterboards.ca.gov/water_issues/programs/ciwqs/publicreports.shtml
State Water Resources Control Board (State Board), 2012. Order Number 2012-0006-DWQ, National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities.
State Water Resources Control Board (State Board), 2013a. Order Number 2013-0001-DWG, National Pollutant Discharge Elimination System (NPDES) General Permit for Waste Discharge Requirements for Discharges from Small Separate Storm Sewer Systems (MS4s).
State Water Resources Control Board (State Board), 2013b. California Environmental Protection Agency, Surface Water Ambient Monitoring Program, Tools for Assessing the Biological Integrity of Surface Waters. Website visited October 2013. Website last updated October 4, 2013. http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml
Sutula, M., J.N. Collins, A. Wiskind, C. Roberts, C. Solek, S. Pearce, R. Clark, A. E. Fetscher, C. Grosso, K. O'Connor, A. Robinson, C. Clark, K. Rey, S. Morrissette, A. Eicher, R. Pasquinelli, M. May, K. Ritter. 2008. Status of Perennial Estuarine Wetlands in the State of California. Surface Water Ambient Monitoring Program, State Water Resource Control Board. Southern California Coastal Water Research Project Technical Report 571.

United States Environmental Protection Agency (USEPA), 2007. Technology Transfer Network Air Toxics Web Site, Pentachlorophenol. Website visited October 2013. Website last updated November 6, 2007. http://www.epa.gov/ttnatw01/hlthef/pentachl.html.
United States Environmental Protection Agency (USEPA). 2009. USEPA Office of Water—TMDL Program Results Analysis Fact Sheet. Fact Sheet: Introduction to Clean Water Act (CWA) Section 303(d) Impaired Waters Lists. Available at http://www.epa.gov/owow/tmdl/results/pdf/aug_7_introduction_to_clean.pdf
United States Environmental Protection Agency (USEPA), 2012a. Water: Total Maximum Daily Loads (303d) Glossary. Website visited November 2013. Website last updated May 21, 2012. http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/glossary.cfm.
United States Environmental Protection Agency (USEPA), 2012b. 2012 Recreational Water Quality Criteria. December, 2012. http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/factsheet2012.pdf
United States Environmental Protection Agency (USEPA), 2012c. Water: Basic Information about Regulated Drinking Water Contaminants. Basic Information about Pentachlorophenol in Drinking Water. Website visited October 2013. Website last updated May 21, 2012. http://water.epa.gov/drink/contaminants/basicinformation/pentachlorophenol.cfm.
United States Environmental Protection Agency (USEPA), 2013. Mercury: Basic Information. Website visited October 2013. Website last updated July 9, 2013. http://www.epa.gov/mercury/about.htm
United States Geological Survey (USGS). 1997. Mercury Contamination of Aquatic Ecosystems. Accessed April 30, 2012. http://water.usgs.gov/wid/FS_216-95/FS_216-95.html
World Resources Institute (WRI), 2013. Eutrophication and Hypoxia, Nutrient Pollution in Coastal Waters, About Eutrophication. Website Visited 2013. http://www.wri.org/our-work/project/eutrophication-and-hypoxia/about-eutrophication

APPENDIX D.2

Third Party Data Sources Summary

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Document:
San Diego Coastkeeper Data for San Dieguito Watershed

Locations within watershed:
SGT-020, SGT-025, SGT-028 (San Dieguito River Below Lake Hodges)

Conditions:
• With the exception of SGT-028, sites were generally above standard levels of dissolved oxygen. 31% of SGT-028 samples were below DO standards.
• Generally low levels of *E. coli*. All sites monitored had *E. coli* levels above regulatory thresholds for less than 10% of the samples.
• Moderate levels of *Enterococcus*. *Enterococcus* samples exceeded regulatory thresholds for 25-31% of the samples, depending on site.
• Ammonia and Phosphorus levels are generally problematic in this area, with exceedances reaching up to 64% of the samples exceeding ammonia thresholds at SGT-020 and 74% of samples exceeding phosphorus thresholds at SGT-025.

Sources:
No Data

Strategies:
No Data

Document:
CSDM Analytical Data COSB, 2010-2012

Locations within watershed:
Seascape Sur (Coastal Storm Drain Outfall to Coastal Receiving Water in Solana Beach)

Conditions:
• Generally, the outfall water has bacteria levels in exceedance of WQOs but the receiving water does not.

Sources:
No Data

Strategies:
No Data

Document:
City of Escondido JURMP, 2002

Locations within watershed:
Lake Hodges, Felicita Creek, Kit Carson Creek

Conditions:
At the time, proposed additions and modifications to the 303(d) list being circulated by the RWQCB included Felicita Creek as a low priority for total dissolved solids (TDS); Lake Hodges as a low priority for color, nitrogen, phosphorus, and TDS; and Kit Carson Creek as a low priority for TDS. These locations were also deemed environmentally sensitive areas.

Sources:
Potential sources include, but are not limited to, the following: roads, streets, and highways; flood control devices (Escondido Creek); sanitary sewage collection; the MS4; fixed municipal facilities; industrial sites; commercial sites; construction sites; residences; sewage discharges from encampments; groundwater seepage, sediment/vegetation in channels; litter and debris. Note: City of Escondido did not consider local runoff to contribute significantly to the proposed 303(d) listing of Lake Hodges.

Strategies:
Include but are not limited to:

- Review and prioritization of different types of facilities and uses
- Water quality monitoring programs
- Structural and nonstructural BMPs
- Education
- Control and management (i.e. erosion control, materials management)
- Regulation (i.e. Stormwater Management Requirements)
- Investigation and abatement of illicit discharges

Document:
City of Escondido JURMP Annual Report, 2012

Locations within watershed:
Felicita Creek, Lake Hodges, Kit Carson Creek

Conditions:
Fifteen stations were above the nitrate action level (26 percent of all stations sampled), and one station was above the action level for total coliform, fecal coliform and *Enterococcus* (less than 2 percent of all stations sampled).
*Disclaimer- JURMP did not indicate if these stations were within San Dieguito Watershed.
The majority of the city's area within this watershed drains to Felicita and Kit Carson creeks and ultimately Lake Hodges.
Within the San Dieguito Watershed, the following CWA §303(d)-listed waterbodies are located in Escondido and are currently listed as being impaired for the following constituents:

- Felicita Creek: aluminum, TDS
- Lake Hodges: color, manganese, mercury, nitrogen, pH, phosphorus, turbidity
- Kit Carson Creek: pentachlorophenol, TDS

Sources:
Potential sources include, but are not limited to, the following: roads, streets, and highways; sanitary sewage collection; the MS4; industrial sites; commercial sites; construction sites; residences; groundwater seepage; agriculture; current or historical presence of septic systems; wildlife; fixed municipal facilities (including Corporate Yard; power washing; and pesticides, herbicides, and fertilizers.

Strategies:
• Similar to previous JURMP with addition of HMP and new permits (ex. 2010-0014-DWQ)

Document:
City of Solana Beach JURMP Annual Report, 2012

Locations within watershed:
San Dieguito Lagoon (and its tributary, Stevens Creek) as well as Pacific Shoreline

Conditions:
Elevated bacteria levels at Seascape Sur
San Dieguito Lagoon (and its tributary, Stevens Creek)- 303(d) listed for Coliform and TDS
Pacific Ocean Shoreline listed for coliform

Sources:
Include, but are not limited to: construction; parking lots, streets and roads; Public Works Yard; industrial facilities (Baker Iron Works); commercial facilities (Beachwalk Business Complex); residences (condominiums).

Strategies:
• Continue implementation of the JURMP to further reduce and eliminate pollutant discharges into the City's MS4 system.
• Continue to implement the LID, HMP and new SUSMP requirements on priority projects.
• Continued use of outside consultants to assist with commercial/Industrial facility inspections, dry weather monitoring program, and department-specific specialized staff trainings.
• Continue updating commercial/industrial inventory as new businesses are established.
• Continue educating the public about the importance of eliminating storm water runoff from residences, businesses, construction sites, and public facilities.
• Preparation for new permit requirements.
• Bacteria specific- BioClean filter in an upstream catch basin above Seascape Sur outfall

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Document:
Public Input Form from Drew (for Mike Kelly per conversation)

Locations within watershed:
Near Park Village Elementary

Conditions:
No Data

Sources:
No Data

Strategies:
• Restoration/treatment at the City/County owned parcels near Park Village Elementary. Site previously evaluated by MWWD- call Kelly Balo

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Document:
City of San Diego San Dieguito Bacteria and Nutrients TMDL- Watershed Characterization Study prepared by AMEC, 2011

Locations within watershed:
San Dieguito River south of Lake Hodges, Green Valley Creek, Boden Creek
Conditions:

Table 1-1: Water Bodies on the 2010 State Board Section §303(d) List in San Dieguito River Watershed

Water Body Name	HSA	HSA No.	Constituent
Pacific Ocean Shoreline at San Dieguito Lagoon Mouth	Rancho Santa Fe	905.11	Indicator bacteria
San Dieguito River	Rancho Santa Fe	905.11	Enterococci, fecal coliform, nitrogen, phosphorus, TDS, and toxicity
Green Valley Creek	Del Dios	905.21	Sulfates, chloride, manganese, and pentachlorophenol (PCP)
Lake Hodges	Del Dios	905.21	Color, nitrogen, phosphorus, turbidity, manganese, mercury and pH
Kit Carson Creek	Del Dios	905.21	Total dissolved solids (TDS) and PCP
Felicita Creek	Felicita	905.23	TDS and aluminum
Cloverdale Creek	Highland	905.32	Phosphorus and TDS
Sutherland Reservoir	Sutherland	905.53	Color, manganese, iron, pH and total nitrogen
Santa Ysabel Creek	Sutherland	905.53	Toxicity

HSA = Hydrologic Sub Area
TDS = Total dissolved solids
PCP = Pentachlorophenal
Source: SWRCB, 2010.

Dry weather:
Generally, analytical results were below WQOs. Constituents that exceeded WQOs during dry weather include chloride, sulfate, TDS, total nitrogen, total phosphorus, turbidity, total metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, iron, manganese, nickel, selenium, and thallium), enterococci, and fecal coliform. Calculated event mean concentration (EMC) results varied across most sites and parameters; however, total metals and total nitrogen were above WQOs at all sites for dry weather events. These results suggest constituent concentrations remained elevated throughout the dry season at all sites.

Wet weather:
Constituents that exceeded water quality objectives during wet weather include nitrite, TDS, total nitrogen, total phosphorus, turbidity, total metals (arsenic, cadmium, chromium, nickel and selenium), enterococci, fecal coliform and total coliform. Calculated EMC results varied across

most sites and parameters; however, total nitrogen, total phosphorus, and total metals were above WQOs at all sites for both wet weather events. This suggests those constituent concentrations remained elevated throughout the storm hydrographs at all sites. Indicator bacteria were above the WQOs at both the mixed land use site, LC-1 (MIXED), and the urbanized site, SDC-TWAS-1 (URBAN). However, indicator bacteria was within the WQO at the reference site, BC-1(REF) during Wet Weather 1, indicating during wet weather, land use may potentially influence bacteria concentrations.

Sources:
Urbanization

Strategies:
• Verify land use characterization
• Characterize how pollutants vary between wet and dry season.
• Bioassessment.

Document:
San Dieguito Watershed Management Plan, input from Consultation Committee

Locations within watershed:
Not specified.

Conditions:
The priority conditions were identified as:
• Nutrients/eutrophication/oxygen depletion
• Silt and Sediment
•Toxicity
• Pathogens in water
• Salinity and dissolved solids
• Litter/trash/debris

Sources:
The priority sources were identified as:
• Increased Development, which could result in an increase in urban stormwater discharges which could contribute nutrients, suspended solids, bacteria, metals, and organics.
• Agricultural and Turf Related Activities which could contribute sediments, nutrients, pesticides, and bacteria

Strategies:
The WMP identifies 6 main programmatic elements in addition to the municipal requirements:
• Reduce hardscape
• Reduce ongoing discharge impairments
• Actions to evaluate and implement land-use BMPs
• Actions to reduce erosion
• Actions to reduce litter
• Education

Document:
City of San Diego Strategic Plan for Watershed Activity Implementation, input from Consultation Committee

Locations within watershed:
Not specified.

Conditions:
The priority conditions were identified as:
• Bacteria
• Nutrients
• Total Dissolved Solids

Sources:
Potential Sources include:
• Eating and Drinking Establishments
• Residential Areas and Activities
• Commercial Landscaping
• Animal Related Facilities
• Golf Courses, Parks, and Recreational Activities
• Municipal Facilities and Activities
• Auto Related Facilities
• Roads, Streets, Highways, and Parking Facilities
• Construction Activities

Strategies:
No data (Strategies identified through 2011 only)

Document:
City of San Diego Public Utilities Department Lake Hodges Watershed Monitoring Data, 2013

Locations within watershed:
The following creeks above Sutherland reservoir
• Bloomdale Creek
• Witch Creek
The following creeks above Lake Hodges
• Temescal Creek
• Sycamore Creek
• Kit Carson Creek
• Del Dios Creek
• Felicita Creek
• Green Valley Creek
• Moonsong Creek
• Santa Maria Creek
• Guejito Creek
• Santa Ysabel Creek
• Cloverdale Creek

Conditions:
No Data

Sources:
No Data

Strategies:
• Collaboration with water agencies to study the Lake Hodges Nutrients issue. Monitoring locations were provided in the attached map.

Document:
Download SWAMP data from CEDEN website using the following search parameters – San Diego County and SWAMP RWB 9 Monitoring

http://ceden.waterboards.ca.gov/AdvancedQueryTool

Locations within watershed:
See red highlighted waterbodies in the table on Page C-14.

Conditions:
SWAMP monitoring data available from CEDEN for Region 9 was reviewed to determine if the data provide additional priority water quality conditions. Many of the programs included 1 -4 sampling events and measured a range of parameters. A majority of the monitoring occurred before the 2005 and 2011 LTEAs that incorporated the most recent regional monitoring data for the region. No additional conditions were selected based on a review of the data.

Sources:
No Data

Strategies:
No Data

Project Name from CEDEN	Years	Station Name(s)	Temporal	No. of Sampling Events	Matrix	Summary of General Analyses
Statewide Project Urban Pyrethroid Status Monitoring		Peñasquitos Creek @ Springbrook	dry weather	1	sediment	TOC, % fines, moisture, and pyrethroids
RWB9 Status Sampling 2008	2008	Campo Creek 1, Ironside Creek, Los Peñasquitos Creek 6, Rose Canyon Creek 4	dry weather	1	water, benthic	field measurements, comments noted, velocity, algae, and conventional chemistry
RWB9 Rotational BA Monitoring 2005	2005	Santa Ysabel Creek ~2mi E Hwy 79	dry weather	1	physical	field measurements, velocity, and slope profile
RWB9 Rotational Monitoring 2002	2002	Los Peñasquitos Creek 6, Poway Creek 2, Rose Canyon Creek 4, Soledad Canyon Creek 2, and Soledad Canyon Creek 4	dry weather	1-4	water, sediment	field measurements, conventional chemistry, metals, herbicides, pesticides, and velocity. % fines
RWB9 Rotational Monitoring 2003	2003	Green Valley Creek 2, San Dieguito River 9, Santa Ysabel Creek 1	dry weather	2-4	water, sediment	Field measurements, conventional chemistry, metals, herbicides, pesticides, and velocity. % fines
San Diego Regional Board Fire Study	2005, 2007, 2008, 2009	Black Mountain Creek Upstream of Santa Ysabel Creek, Boden Canyon Creek (BOD), Boden Canyon Creek ~0.5 mile upstream of Santa Ysabel Creek , Chicarita Creek downstream of Evening Creek Road, Green Valley Creek 2, Kit Carson Creek Sunset Drive crossing	dry weather	1-3	water	field measurements and velocity
Statewide Perennial Streams Assessment 2008	2008	Encinitas Creek, Arroyo Trabuco 57, Santa Ysabel Creek	dry weather	1	water, benthic	field measurements, comments noted, velocity, algae, and conventional chemistry
CMAP Wadeable Streams 2004	2004	Santa Ysabel Creek below Witch Creek	dry weather	2	water	field measurements and velocity

continued on next page

Project Name from CEDEN	Years	Station Name(s)	Temporal	No. of Sampling Events	Matrix	Summary of General Analyses
Statewide Ref Condition Management Plan 2009	2009	Noble Canyon Creek ~0.8mi above Pine Valley Cr.	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2010	2010	Cedar Creek 2, Japacha Creek above Hwy 79, Spring Canyon Creek ~2.3mi above Hwy 74	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2008	2008	Arroyo Trabuco	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2011	2011	Cold Spring Canyon above Devil Cyn Creek, Devils Canyon Creek above San Mateo Cyn. Creek, Juaquapin Creek above Sweetwater River, Kitchen Creek at Kitchen Creek Road, Troy Canyon Creek (TCC2), Wilson Creek 3	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Mgmt Plan Index Study 2009	2009	Noble Canyon Creek ~0.8mi above Pine Valley Cr.	dry weather	2	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Mgmt Plan Index Study 2010	2010	Cedar Creek 2	dry weather	4	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Stream Pollution Trends Study 2008	2008, 2009, 2010	Agua Hedionda Creek 6, Escondido Creek at Camino del Norte, Forrester Creek 2, Los Peñasquitos Creek 6, San Diego River at Ward Road, San Dieguito River 9, San Juan Creek 9, Santa Margarita at Basilone Rd, Soledad Canyon Creek 4, Tijuana River at Hollister Rd	dry weather	1	sediment	Organics, PCBs, Pyrethroids, Pesticides, Semi-volatile Organic Carbons, metals

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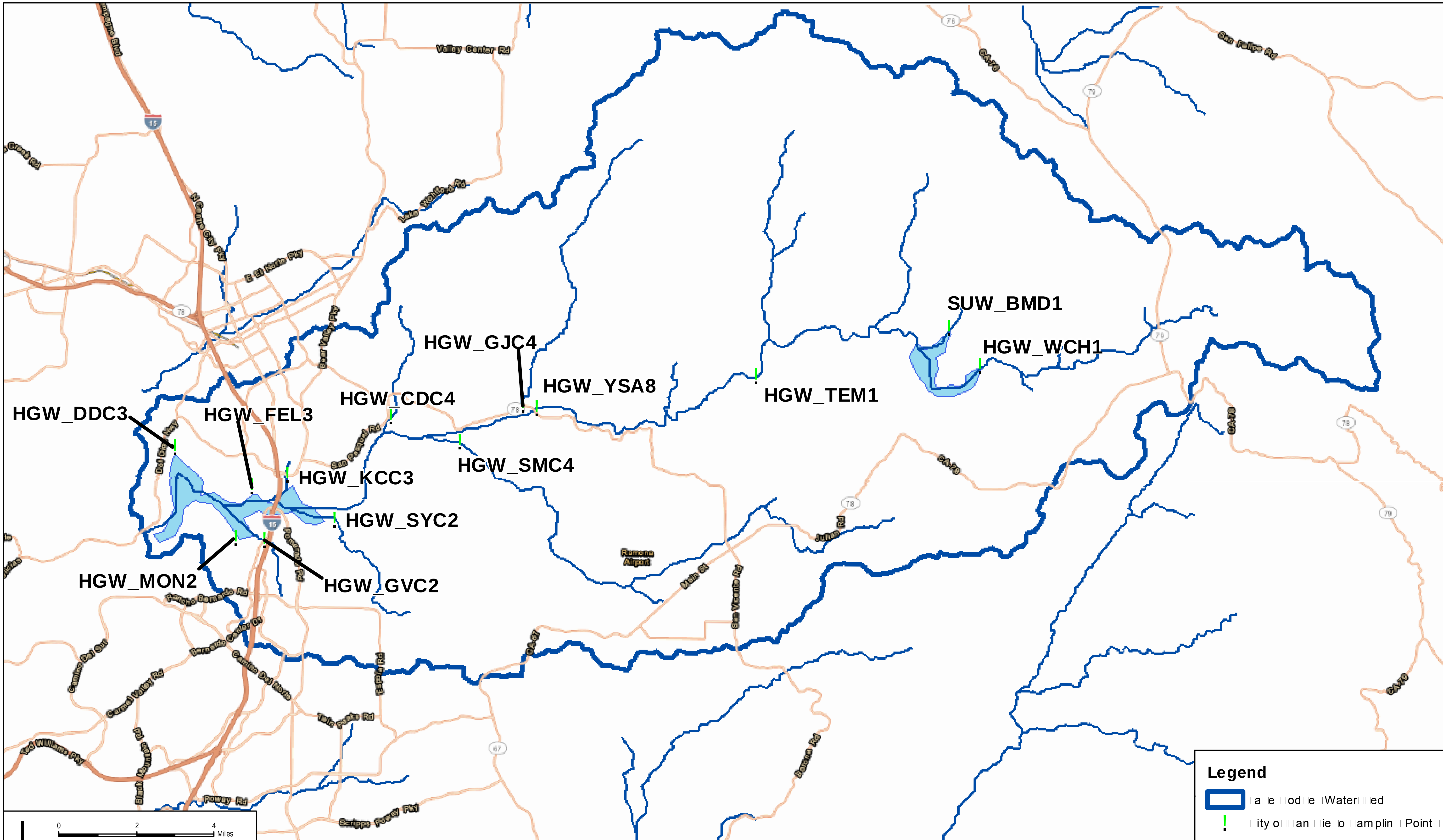

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DECEMBER 2013

SOURCE: ESRI World Imagery - USGS NED 2011 (30 meter)

FIGURE 1

Lake Hodges Watershed - Water Quality Sampling Points

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APPENDIX D.3

Persistent Flow Outfall Summary

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Persistent Flow Outfalls

Jurisdiction[2]	Subwatershed	Site ID	Latitude	Longitude	Land Use
City of San Diego[3]	San Dieguito River Above Lake Hodges	DW0001	33.05223	-117.06648	Residential
		DW0005	33.04143	-117.07826	Residential
		DW0317	33.03057	-117.08524	Residential
		DW0689	33.01889	-117.06148	Residential
	San Dieguito River Below Lake Hodges	DW0033	32.97831	-117.24773	Residential/Open Space
		DW0284	32.96657	-117.21472	Residential/Open Space
		DW0332	33.01393	-117.14438	Residential
		DW0333	33.0119	-117.14565	Residential
		DW0636	33.01472	-117.09381	Industrial/Commercial
		DW0759	33.99998	-117.08625	Residential
County of San Diego	San Dieguito River Below Lake Hodges	SDG-074	33.01878	-117.10689	Industrial
		SDG-080	33.00303	-117.11605	Residential
		SDG-115	33.04092	-117.15749	Rural Residential
City of Del Mar	San Dieguito River Below Lake Hodges	S-06	32.95992	-117.26825	Commercial, Residential & Parks
		S-07	32.96245	-117.26829	Commercial & Residential
City of Escondido	San Dieguito River Above Lake Hodges	HDG_102	33.06951	-117.07135	Freeway/Road/Transportation
City of Poway	San Dieguito River Above Lake Hodges	54	33.00880	-117.02430	Open Space/Parks
		140	33.03204	-117.04781	Open Space/Parks

1. This list of persistent flow outfalls is current based on 2014 dry weather monitoring data.
2. No persistent flow outfalls have been identified in the City of Solana Beach. Low flow diverters have been installed in all previously identified persistent flow outfalls.
3. Identified land uses for the City of San Diego include all land uses comprising more than 30% of upstream drainage area.

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APPENDIX D.4

Public Input from Water Quality Improvement Plan Workshop

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Public Input

Priority Water Quality Conditions

- Manganese in Lake Hodges, bromides
- Dissolved oxygen in Lake Hodges
- Priorities based on human health conditions
- Nutrients, ammonia, bacteria below Lake Hodges, N&P
- Mosquitoes, vector control
- Nutrients in Lake Hodges. Limits use for water supply and costs to treat this problem
- Stagnant water
- Mercury in Lake Hodges

Sources

- Sewer discharges/septic
- San Pasqual Valley/Safari Park
- Agricultural
- Lots of urban landscaping and impervious surfaces
- Car washing
- Brownfield runoff
- Groundwater contamination
- Fertilizer

Potential Water Quality Strategies

- Fertilizer management
- Public education campaigns about fertilizers and other contaminants
- Integration of smaller and regional BMPs
- Focus on larger projects – more cost efficiency
- Constructed wetlands
- Vegetated swales, different scalp, different locations
- Detention basins
- Catch basin approaches for existing development that captures urban drool and first flush

- En-lieu fee/alternative compliance
- More pervious surfaces for parking lots
- Community gardens
- Hypo - oxygen cycling in late ___?
- Landscape retrofitting at homes
- Optimize street sweeping before rainy season
- Enforce parking restrictions for sweeping
- Vegetated and retention facilities in habitat preservation areas
- Effective social change/marketing
- Pet waste retrieval and delivery – quirky English program
- Education on off road impacts to water quality
- Restoration/treatment at City/County owned parcels near Park Village Elementary. Site was previously evaluated by MWWD

<u>Data</u>

- Water utility data under IDWRM for Lake Hodges
- San Dieguito River Park modeling for nutrients
- Grant apps under IRWM (strategy)
- UCSD "Oasis" project for water quality monitoring at Salton Sea
- Satellite photography/R.E. photography, Arial photo bank.

APPENDIX E

Receiving Water Condition and Urban Runoff Assessment

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Table of Contents

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Appendix E –Receiving Water Condition and Urban Runoff Assessment

Appendices E.1 and E.2 present an assessment of receiving water conditions and the impact of urban discharges in San Dieguito River WMA during wet and dry weather, respectively. The list of receiving water conditions was developed on the basis of the 2010 303(d) list, applicable TMDLs, waterbodies with special biological significance, public input, and the priority pollutants or stressors identified from current and historical receiving water monitoring data. MS4 monitoring data compiled from the LTEA and WURMP Annual Reports, as well as any applicable TMDL WQBELs, are also evaluated in relation to the receiving water conditions to determine if a priority water quality condition existed.

The tables in Appendices E.1 and E.2 are presented by WQIP Subwatershed and 303(d) listed waterbody. In order to mirror the process used by the Responsible Agencies to assess the potential receiving water conditions for each waterbody, the data are presented in the order they were evaluated. The following is an illustration of how the reader might follow the process used to assess receiving water conditions in an example waterbody (Example Waterbody A):

- **303(d) Listings (Page E-5, reading left to right)** identifies the WQIP subwatershed, applicable TMDLs, and 303(d) listed waterbody (Example Waterbody A), and then presents the associated pollutants, impaired beneficial uses, and potential sources of impairment for Example Waterbody A as identified under the 2010 303(d) list.
- **Receiving Water Assessment and Conditions (Page E-6, reading left to right)**
  - **Receiving Water Assessment** identifies the WQIP subwatershed, applicable TMDLs, and 303(d) listed waterbody (Example Waterbody A), and then presents public input submitted in response to the public data call and NPDES receiving water monitoring station data for Example Waterbody A. The receiving water priorities identified were noted as exceeding water quality benchmarks in the 2005-2010 LTEA, the FY 11 & 12 WURMP, or both.
  - **Receiving Water Conditions** summarizes the receiving water conditions identified through the 303(d) listings and receiving water assessment, and states the applicable lines of evidence.
- **Urban Runoff Monitoring Assessment (Page E-7, reading left to right)** identifies the WQIP subwatershed and 303(d) listed waterbody (Example Waterbody A), and then presents the priority pollutants at the MS4 outfall, based on the Urban Runoff Monitoring Program and identified in the 2005-2010 LTEA and FY 11&12 WURMP Annual Reports, for Example Waterbody A. as well as the applicable WQBELs where appropriate.

Page E-8 then restarts the assessment with an evaluation of 303(d) listings for the next waterbody.

APPENDIX E.1

Wet Weather Receiving Water Condition Assessment

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WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	Phosphorus	Warm Fresh Water Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			TDS	Agricultural Supply	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
		Felicita Creek	Aluminum	Municipal & Domestic Supply	Unknown
			TDS	Municipal & Domestic Supply	Agricultural Return Flows, Flow Regulation/Modification, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Green Valley Creek	Chloride	Municipal & Domestic Supply	Unknown
			Manganese	Municipal & Domestic Supply	Unknown
			PCP	Municipal & Domestic Supply	Unknown
			Sulfates	Municipal & Domestic Supply	Unknown Point Source, Urban Runoff/Storm Sewers, Natural Sources, and Unknown Non-point Sources
		Kit Carson Creek	PCP	Municipal & Domestic Supply	Unknown
			TDS	Municipal & Domestic Supply	Agricultural Return Flows, Flow Regulation/Modification, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	No Input	SDC-TWAS-1, SDC-TWAS-2	Chlorpyrifos, Bifenthrin, BOD, COD, TSS, Turbidity, pH, Ammonia as N, Surfactants (MBAS), Toxicity (*H. azteca* acute), Fecal Coliform, Total P, Nitrate as N, TDS	Toxicity (*S. capricornutum* acute), Very Poor IBI, Fecal Coliform, *Enterococcus* , Total P, Dissolved P, TDS	Phosphorus not included because impact to WARM during wet weather is unknown. Phosphorus will be listed as contributing to impairment of WARM during dry weather.	
							TDS not included because impact to AGR during wet weather is unknown. TDS will be listed as contributing to impairment of AGR during dry weather.	
		Felicita Creek	No Input				Impairment of MUN due to aluminum in Felicita Creek during wet weather.	303(d)
							TDS not included because impact to MUN during wet weather is unknown. TDS will be listed as contributing to impairment of MUN during dry weather.	
		Green Valley Creek	No Input				Impairment of MUN due to chloride, manganese, and PCP in Green Valley Creek during wet weather.	303(d)
							Sulfates not included because impact to MUN during wet weather is unknown. Sulfates are listed as contributing to impairment of MUN during dry weather.	
		Kit Carson Creek	No Input				Impairment of MUN due to PCP in Kit Carson Creek during wet weather	303(d) (MS4 program does not monitor for PCP)
							TDS is not included because impact to MUN during wet weather is unknown. TDS will be listed as contributing to impairment of MUN during dry weather.	

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	TSS, Fecal Coliform	Fecal Coliform, TDS	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Felicita Creek			
		Green Valley Creek			
		Kit Carson Creek			

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	Color	Municipal & Domestic Supply	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Manganese	Municipal & Domestic Supply	Unknown
			pH	Municipal & Domestic Supply	Unknown
			Mercury	Municipal & Domestic Supply, Commercial/ Recreational Collection of Fish, Shellfish, or Organisms	Unknown
			Nitrogen	Municipal & Domestic Supply	Agriculture, Dairies, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Phosphorus	Municipal & Domestic Supply	Agriculture, Dairies, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Turbidity	Municipal & Domestic Supply	Unknown
			NA	NA	NA

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	No Input	SDC-TWAS-1, SDC-TWAS-2	Chlorpyrifos, Bifenthrin, BOD, COD, TSS, Turbidity, pH, Ammonia as N, Surfactants (MBAS), Toxicity (*H. azteca* acute), Fecal Coliform, Total P, Nitrate as N, TDS	Toxicity (*S. capricornutum* acute), Very Poor IBI, Fecal Coliform, *Enterococcus* , Total P, Dissolved P, TDS	Impairment of MUN due to color, manganese, pH, and mercury in Lake Hodges during wet weather	303(d) (MS4 program does not monitor for manganese, pH, color, or mercury)
							Nitrogen and phosphorus not included because impacts to WARM during wet weather are unknown. Nitrogen and phosphorus will be listed as contributing to impairment of WARM during dry weather.	
							Impairment of MUN due to turbidity in Lake Hodges during wet weather	303(d) and historical data
							Exceedance of fecal coliform WQO at NPDES RW station during wet weather	RW monitoring data (historical and current) and Bacteria TMDL

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	TSS, Fecal Coliform	Fecal Coliform, TDS	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	Toxicity	Warm Fresh Water Habitat	Unknown Non-point Source
		Sutherland Reservoir	Color	Municipal & Domestic Supply	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Iron	Municipal & Domestic Supply	Unknown
			Manganese	Municipal & Domestic Supply	Unknown
			pH	Municipal & Domestic Supply	Unknown
			Total Nitrogen as N	Warm Freshwater Habitat	Natural, Unknown, and Unknown Point Sources

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	No Input	NA	NA	NA	Impairment of WARM due to toxicity in Santa Ysabel Creek during wet weather	303(d)
		Sutherland Reservoir					Impairment of MUN due to color, iron, manganese, and pH in Sutherland Reservoir during wet weather	303(d)
							Total nitrogen not included because impact to WARM during wet weather is unknown. Total nitrogen will be listed as contributing to impairment of WARM during dry weather.	

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	NA	NA	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Sutherland Reservoir			

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Below Lake Hodges	Bacteria TMDL	San Dieguito River	*Enterococcus*	Water Contact Recreation	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Fecal coliform	Water Contact Recreation	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Nitrogen	Warm Freshwater Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Phosphorus	Warm Freshwater Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			TDS	Warm Freshwater Habitat	Unspecified Non-point Source, Unspecified Point Source
			Toxicity	Warm Freshwater Habitat	Unknown

<table>
<tr><th rowspan="3">WQIP Subwatershed</th><th rowspan="3">TMDL</th><th rowspan="3">303(d) Listed Waterbody</th><th colspan="4">Receiving Water Assessment</th><th colspan="2">Receiving Water Conditions</th></tr>
<tr><th rowspan="2">Public Input</th><th colspan="3">NPDES Receiving Water</th><th rowspan="2">Receiving Water Conditions</th><th rowspan="2">Line(s) of Evidence</th></tr>
<tr><th>Applicable Receiving Water Station(s)</th><th>2005-2010 LTEA</th><th>FY 11 & 12 WURMP</th></tr>
<tr><td rowspan="4">San Dieguito River Below Lake Hodges</td><td rowspan="4">Bacteria TMDL</td><td rowspan="4">San Dieguito River</td><td rowspan="4">No Input</td><td rowspan="4">MLS (Below Lake Hodges)</td><td rowspan="4">TSS, Turbidity, Bifenthrin, Toxicity (C. dubia reproduction, S. capricornutum acute), Fecal Coliform, TDS</td><td rowspan="4">Toxicity (C. dubia reproduction), Very Poor IBI, Fecal Coliform, TDS</td><td>Impairment of REC-1 due to Enterococcus and fecal coliform in San Dieguito River during wet weather</td><td>303(d) and RW monitoring data (historical & current), and Bacteria TMDL</td></tr>
<tr><td colspan="2">Nitrogen and phosphorus not included because impact to WARM during wet weather is unknown. Nitrogen and phosphorus will be listed as contributing to impairment of WARM during dry weather.</td></tr>
<tr><td colspan="2">TDS not included because impact to WARM during wet weather is unknown. TDS will be listed as contributing to impairment of WARM during dry weather.</td></tr>
<tr><td>Impairment of WARM due to toxicity in San Dieguito River during wet weather</td><td>303(d) and RW monitoring data (historical & current)</td></tr>
</table>

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Below Lake Hodges	Bacteria TMDL	San Dieguito River	Fecal Coliform	Fecal Coliform	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	Indicator Bacteria	Water Contact Recreation	Unknown Non-point Source, Urban Runoff, Unknown Point Source
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth	Total Coliform	Shellfish Harvesting	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	No Input	MLS (Below Lake Hodges)	TSS, Turbidity, Bifenthrin, Toxicity (*C. dubia* reproduction, *S. capricornutum* acute), Fecal Coliform, TDS	Toxicity (*C. dubia* reproduction), Very Poor IBI, Fecal Coliform , TDS	Impairment of REC-1 due to indicator bacteria at the Pacific Ocean Shoreline during wet weather	Bacteria TMDL
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth	No Input				Impairment of SHELL due to total coliform at the Pacific Ocean Shoreline during dry weather.	303(d)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	Fecal Coliform	Fecal Coliform	*Enterococcus* , Fecal Coliform, Total Coliform (Order No. R9-2013-0001; Attachment E.6)
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth			

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APPENDIX E.2

Dry Weather Receiving Water Condition Assessment

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WQIP Sub-watershed	TMDL	303(d) Listed Water-body	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	Phosphorus	Warm Fresh Water Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			TDS	Agricultural Supply	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
		Felicita Creek	Aluminum	Municipal & Domestic Supply	Unknown
			TDS	Municipal & Domestic Supply	Agricultural Return Flows, Flow Regulation/Modification, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Green Valley Creek	Chloride	Municipal & Domestic Supply	Unknown
			Manganese	Municipal & Domestic Supply	Unknown
			PCP	Municipal & Domestic Supply	Unknown
			Sulfates	Municipal & Domestic Supply	Unknown Point Source, Urban Runoff/Storm Sewers, Natural Sources, and Unknown Non-point Sources
		Kit Carson Creek	PCP	Municipal & Domestic Supply	Unknown
			TDS	Municipal & Domestic Supply	Agricultural Return Flows, Flow Regulation/Modification, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Receiving Water Assessment						Receiving Water Conditions	
			Public Input	NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	No Input	SDC-TWAS1, SDC-TWAS-2	BOD, TSS, Turbidity, Surfactants (MBAS), Toxicity (*C. dubia*), Very Poor IBI, O/E, *Enterococcus* , Total N, Benthic Algae, Total P	Toxicity (*S. capricornutum* acute, C. dubia reproduction), Very Poor IBI, *Enterococcus* , Total P, Dissolved P, TDS	No Data	Sulfates, Poor IBI, Total N, Total P, TDS	Impairment of WARM due to eutrophication (phosphorus) in Cloverdale Creek during dry weather.	303(d) and RW monitoring data (historical & current)
									Impairment of AGR due to TDS in Cloverdale Creek during dry weather.	303(d) and RW monitoring data (historical & current)
		Felicita Creek	No Input						Impairment of MUN due to aluminum in Felicita Creek during dry weather.	303(d)
									Impairment of MUN due to TDS in Felicita Creek during dry weather.	303(d) and RW monitoring data (historical & current)
		Green Valley Creek	No Input						Impairment of MUN due to chloride, manganese, and PCP in Green Valley Creek during dry weather.	303(d)
									Impairment of MUN due to sulfates in Green Valley Creek during dry weather.	303(d) and RW monitoring data (historical & current)
		Kit Carson Creek	No Input						Impairment of MUN due to PCP in Kit Carson Creek during dry weather.	303(d) (MS4 program does not monitor for PCP)
									Impairment of MUN due to TDS in Kit Carson Creek during dry weather.	303(d) and RW monitoring data (historical & current)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Urban Runoff Monitoring Assessment[a]		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Lake Hodges	Bacteria TMDL	Cloverdale Creek	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, Dissolved P, TDS	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Felicita Creek			
		Green Valley Creek			
		Kit Carson Creek			

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	Color	Municipal & Domestic Supply	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Manganese	Municipal & Domestic Supply	Unknown
			pH	Municipal & Domestic Supply	Unknown
			Mercury	Municipal & Domestic Supply	Unknown
			Nitrogen	Municipal & Domestic Supply	Agriculture, Dairies, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Phosphorus	Municipal & Domestic Supply	Agriculture, Dairies, Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Turbidity	Municipal & Domestic Supply	Unknown
			NA	NA	NA

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Receiving Water Assessment						Receiving Water Conditions	
			Public Input	NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	No Input	SDC-TWAS1, SDC-TWAS-2	BOD, TSS, Turbidity, Surfactants (MBAS), Toxicity (*C. dubia*), Very Poor IBI, O/E, *Enterococcus* , Total N, Benthic Algae, Total P	Toxicity (*S. capricornutum* acute, C. dubia reproduction), Very Poor IBI, *Enterococcus* , Total P, Dissolved P, TDS	No Data	Sulfates, Poor IBI, Total N, Total P, TDS	Impairment of MUN due to color, manganese, pH, and mercury in Lake Hodges during dry weather.	303(d) (MS4 program does not monitor for manganese, pH, color, or mercury)
									Impairment of MUN due to eutrophication (nitrogen and phosphorus) in Lake Hodges during dry weather.	303(d) and RW monitoring data (historical & current)
									Impairment of MUN due to turbidity in Lake Hodges during dry weather.	303(d) and historical data
									Elevated *Enterococcus* levels at the NPDES RW station during dry weather.	RW monitoring data (historical and current)
									Poor IBI at the NPDES RW station during dry weather.	RW monitoring data (historical and current).
									Toxicity to *C. dubia* at the NPDES RW station during dry weather.	RW monitoring data (historical and current)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Urban Runoff Monitoring Assessment[a]		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Lake Hodges	Bacteria TMDL	Lake Hodges	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, Dissolved P, TDS	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	Toxicity	Warm Fresh Water Habitat	Unknown Non-point Source
		Sutherland Reservoir	Color	Municipal & Domestic Supply	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Iron	Municipal & Domestic Supply	Unknown
			Manganese	Municipal & Domestic Supply	Unknown
			pH	Municipal & Domestic Supply	Unknown
			Total Nitrogen as N	Warm Freshwater Habitat	Natural, Unknown, and Unknown Point Sources

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Receiving Water Assessment						Receiving Water Conditions	
			Public Input	NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	No Input	NA	NA	NA	NA	NA	Impairment of WARM due to toxicity in Santa Ysabel Creek during dry weather.	303(d)
		Sutherland Reservoir	No Input						Impairment of MUN due to color, iron, manganese, and pH in Sutherland Reservoir during dry weather.	303(d)
									Impairment of WARM due to eutrophication (total nitrogen) in Sutherland Reservoir during dry weather.	303(d)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Urban Runoff Monitoring Assessment[a]		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Above Sutherland Reservoir	Bacteria TMDL	Santa Ysabel Creek (Above Sutherland Reservoir)	NA	NA	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Sutherland Reservoir			

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	303(d) Listings		
			Pollutant(s)	**Impaired Beneficial Use(s)**	**Potential Source(s)**
San Dieguito River Below Lake Hodges	Bacteria TMDL	San Dieguito River	*Enterococcus*	Water Contact Recreation	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Fecal Coliform	Water Contact Recreation	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Nitrogen	Warm Freshwater Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			Phosphorus	Warm Freshwater Habitat	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
			TDS	Warm Freshwater Habitat	Unspecified Non-point Source, Unspecified Point Source
			Toxicity	Warm Freshwater Habitat	Unknown

<table>
<tr><th rowspan="3">WQIP Sub-watershed</th><th rowspan="3">TMDL</th><th rowspan="3">303(d) Listed Water-body</th><th colspan="6">Receiving Water Assessment</th><th colspan="2">Receiving Water Conditions</th></tr>
<tr><th rowspan="2">Public Input</th><th colspan="3">NPDES Receiving Water</th><th colspan="2">SMC Program</th><th rowspan="2">Receiving Water Conditions</th><th rowspan="2">Line(s) of Evidence</th></tr>
<tr><th>Applicable Receiving Water Station(s)</th><th>2005-2010 LTEA</th><th>FY 11 & 12 WURMP</th><th>2005-2010 LTEA</th><th>FY 11 & 12 WURMP</th></tr>
<tr><td rowspan="6">San Dieguito River Below Lake Hodges</td><td rowspan="6">Bacteria TMDL</td><td rowspan="6">San Dieguito River</td><td rowspan="6">Ammonia</td><td rowspan="6">MLS (Below Lake Hodges)</td><td rowspan="6">BOD, Toxicity (S. capricornutum acute), Poor IBI, O/E, Enterococcus, Fecal Coliform, Total N, Benthic Algae, TDS</td><td rowspan="6">Toxicity (C. dubia), Very Poor IBI, Enterococcus, Total N, Total P, Dissolved P, TDS</td><td rowspan="6">Chloride, Sulfates, TSS, Very Poor IBI, O/E, Total N, Benthic Algae, TDS</td><td rowspan="6">NA</td><td>Impairment of REC-1 due to Enterococcus in San Dieguito River during dry weather</td><td>303(d) and RW monitoring data (historical & current), and Bacteria TMDL</td></tr>
<tr><td>Impairment of REC-1 due to fecal coliform in San Dieguito River during dry weather.</td><td>303(d) and RW monitoring data (historical), and Bacteria TMDL</td></tr>
<tr><td>Impairment of unknown conditions due to eutrophication (ammonia)</td><td>Public Input</td></tr>
<tr><td>Impairment of WARM due to nitrogen and phosphorus in San Dieguito River during dry weather.</td><td>303(d)</td></tr>
<tr><td>Impairment of WARM due to TDS in San Dieguito River during dry weather.</td><td>303(d) and RW monitoring data (historical & current)</td></tr>
<tr><td>Impairment of WARM due to toxicity in San Dieguito River during dry weather.</td><td>303(d) and RW monitoring data (historical & current)</td></tr>
</table>

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Urban Runoff Monitoring Assessment[a]		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Below Lake Hodges	Bacteria TMDL	San Dieguito River	*Enterococcus* , Total P, Total N, TDS	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, Dissolved P, TDS	*Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	Indicator Bacteria	Water Contact Recreation	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth	Total Coliform	Shellfish Harvesting	Unspecified Non-point Source, Urban Runoff, Unspecified Point Source

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Receiving Water Assessment						Receiving Water Conditions	
			Public Input	NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	No Input	MLS (Below Lake Hodges)	BOD, Toxicity-S. capricornutum acute, Poor IBI, O/E, Enterococcus, Fecal Coliform, Total N, Benthic Algae, TDS	Toxicity-C. dubia, Very Poor IBI, Enterococcus, Total N, Total P, Dissolved P, TDS	Chloride, Sulfate, TSS, Very Poor IBI, O/E, Total N, Benthic Algae, TDS	NA	Impairment of REC-1 due to indicator bacteria at the Pacific Ocean Shoreline during dry weather.	Bacteria TMDL
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth	No Input						Impairment of SHELL due to total coliform at the Pacific Ocean Shoreline during dry weather.	303(d)

WQIP Sub-watershed	TMDL	303(d) Listed Water-body	Urban Runoff Monitoring Assessment[a]		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
San Dieguito River Below Lake Hodges	Bacteria TMDL	Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth at San Dieguito River Beach	*Enterococcus* , Total P, Total N, TDS	Chloride, Sulfates, *Enterococcus* , Fecal Coliform, Total N, Total P, Dissolved P, TDS	*Enterococcus* , Fecal Coliform, Total Coliform (Order No. R9-2013-0001; Attachment E.6)
		Pacific Ocean Shoreline, San Dieguito HU, at San Dieguito Lagoon Mouth			

[a] No MS4 Outfall and Dry Weather Monitoring Program provided in the FY 11 &12 WURMP.

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APPENDIX F

Receiving Water Conditions, Potential Impacts of MS4 Discharges, and Priority Water Quality Conditions in the San Dieguito River WMA

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Table of Contents

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This appendix contains details of the analysis of receiving water conditions (Section 2.1), impacts from MS4 discharges (Section 2.2), and the factors that were evaluated to develop the final list of priority water quality conditions and high priority water quality conditions. The information is presented in three tables, which are described below.

Table F-1: Receiving Water Conditions and Potential Impacts of MS4 Discharges in the San Dieguito River WMA

Table F-1 presents all identified receiving water conditions in the San Dieguito River WMA and the potential impacts of the MS4 discharges. These conditions were identified as described in Sections 2.1 and 2.2 based on the considerations detailed in the table. These include:

- Available receiving water data (current or historic) or regulatory drivers that support the condition. A check mark in the table indicates that samples have exceeded water quality objectives or the 2010 303(d) list or a TMDL identifies the waterbody as impaired. Where possible, the data were divided by temporal extent (wet- or dry-weather).
- Available current or historic MS4 monitoring data indicating that the MS4 potentially causes or contributes to the condition. A check mark indicates that samples collected from the MS4 during wet- or dry-weather have exceeded water quality objectives. MS4 data from the subwatershed was typically used for this consideration; data for MS4 discharges directly to the receiving water body in question are rarely available.
- Identification of the MS4 as a source of the condition in the 2010 303(d) list or a TMDL.
- The factors that led to the determination that the condition exists and was therefore included in the table.

Table F-2: Priority Water Quality Conditions in the San Dieguito River WMA Subwatersheds

Table F-2 presents the following information for each priority water quality condition per the MS4 Permit (Provision B.2.b):

- The beneficial use impairment(s) associated with the priority water quality condition;
- The pollutant or stressor causing the beneficial use impairment, if known;
- The temporal extent of the priority water quality condition (dry and/or wet weather);

- The geographical extent of the priority water quality condition within the WMA, if known (based on the extent of the associated 303(d) listing or the location of the associated NPDES monitoring location);
- Lines of evidence leading to identification as a priority water quality condition, including evidence of MS4 discharges that may cause or contribute to the condition; and
- An assessment of the adequacy of the monitoring data to characterize the factors causing or contributing to the priority water quality condition, including consideration of spatial and temporal variation.

The table also lists the Responsible Agencies that potentially contribute to the condition. The contents of this table were determined by the assessment of the receiving water conditions and the MS4 impacts (presented in Table F-1).

Table F-3: Evaluation of Priority Water Quality Conditions in the San Dieguito River WMA

As described in Section 2.3, priority water quality conditions that were identified based on the methodology presented in Appendix A. The remaining priority water quality conditions were evaluated based on several factors to determine if they warranted elevation to high priority water quality conditions for this iteration of the Water Quality Improvement Plan. Table F-3 summarizes this evaluation. The priority water quality condition must meet all of the following criteria to be considered a high priority water quality condition:

- Supporting data are sufficient to characterize the receiving water condition. To be sufficient, multiple samples collected under quality controlled monitoring must have exceeded water quality objectives.
- Storm water or non-stormwater runoff is a predominant source. Samples or observations collected under quality controlled monitoring programs must indicate that MS4 discharges are a predominant source of the receiving water condition.
- Controllable by Responsible Agencies. The pollutant or stressor must be within the authority of the Responsible Agency to control. To be considered controllable, there must be a clear link between the MS4 contribution and the receiving water condition, and the potential strategies to address the condition must be applicable to the geographic extent of the condition.
- Cannot be addressed by strategies identified for other high priority water quality condition s. The condition was not elevated to a high priority water quality condition if strategies identified for other high priority water quality conditions are expected to address the condition.

Table F-1
Receiving Water Conditions and Potential Impacts of MS4 Discharges in the San Dieguito River WMA

Subwatershed	Waterbody	Condition	Receiving Water Data or Regulatory Drivers Support Consideration as a Receiving Water Condition		Determining Factor(s) For Receiving Water Data	MS4 Monitoring Data Indicates Potential MS4 Impact		MS4 Listed As Source on 303(d) or TMDL	Elevated to Priority Water Quality Condition?
			Wet	Dry		Wet	Dry		
San Dieguito River Above Sutherland Reservoir	Santa Ysabel Creek (Above Sutherland Reservoir)	Impairment of WARM due to toxicity	✓	✓	2010 303(d)	–	–	–	No; Toxicity cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.
	Sutherland Reservoir	Impairment of MUN due to color	✓	✓	2010 303(d)	–	–	Wet, Dry	Yes
		Impairment of MUN due iron, manganese, and pH	✓	✓	2010 303(d)	–	–	–	No; Iron not assessed under previous MS4 Permit. Manganese and pH were not elevated to a MS4 outfall priority by LTEA or WRMP.
		Impairment of WARM due to eutrophication[1] (nitrogen)	–[1]	✓	2010 303(d)	–	–	–	No; No MS4 data, and based on best professional judgment MS4 impacts on eutrophic conditions are not quantifiable.
San Dieguito River Above Lake Hodges	Cloverdale Creek	Impairment of WARM due to eutrophication[1] (phosphorus)	–[1]	✓	2010 303(d) and historical and current monitoring data	–	✓	Dry	Yes
		Impairment of AGR due to TDS[1]	–[1]	✓	2010 303(d) and historical and current monitoring data	–	✓	Dry	Yes
	Green Valley Creek	Impairment of MUN due to chloride	✓	✓	2010 303(d)	✓	✓	–	Yes
		Impairment of MUN due manganese and PCP	✓	✓	2010 303(d)	–	–	–	No; PCP not assessed under previous MS4 Permit. Manganese was not elevated to a MS4 outfall priority by LTEA or WRMP
		Impairment of MUN due to sulfate	–	✓	2010 303(d) and historical and current monitoring data	–	✓	Dry	Yes
	Kit Carson Creek	Impairment of MUN due to PCP	✓	✓	2010 303(d)	–	–	–	No; PCP not assessed under previous MS4 Permit.
		Impairment of MUN due to TDS[1]	–[1]	✓	2010 303(d) and historical and current monitoring data	–	✓	–	Yes
	Felicita Creek	Impairment of MUN due to aluminum	✓	✓	2010 303(d)	–	–	–	No; Aluminum not assessed under previous MS4 Permit
		Impairment of MUN due to TDS[1]	–[1]	✓	2010 303(d) and historical and current monitoring data	–	✓	Dry	Yes
	Near the NPDES Monitoring Stations	Fecal coliform exceedance at the NPDES receiving water (RW) stations	✓	–	Historical and current monitoring data and Bacteria TMDL at Pacific Ocean Shoreline	✓	–	–	Yes
	Near the NPDES Monitoring Stations	Elevated *Enterococcus* levels at the NPDES RW stations	–	✓	Historical and current monitoring data and Bacteria TMDL at Pacific Ocean Shoreline	–	✓	–	Yes
		Poor IBI scores at the NPDES RW stations	–	✓	Historical and current monitoring data	–	–	–	No; Poor IBI scores cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.
		Toxicity to C. dubia at the NPDES RW stations	–	✓	Historical and current monitoring data	–	–	–	No; Toxicity cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.

Continued on next page

Subwatershed	Waterbody	Condition	Receiving Water Data or Regulatory Drivers Support Consideration as a Receiving Water Condition		Determining Factor(s) For Receiving Water Data	MS4 Monitoring Data Indicates Potential MS4 Impact		MS4 Listed As Source on 303(d) or TMDL	Elevated to Priority Water Quality Condition?
			Wet	Dry		Wet	Dry		
San Dieguito River Above Lake Hodges	Lake Hodges	Impairment of MUN due to color	✓	✓	2010 303(d), public input	–	–	Wet, Dry	Yes
		Impairment of MUN due to manganese, pH, and mercury	✓	✓	2010 303(d), public input	–	–	–	No; Manganese and mercury not assessed under previous MS4 Permit. pH was not elevated to a MS4 outfall priority by LTEA or WRMP.
	Lake Hodges	Impairment of MUN due to turbidity	✓	✓	2010 303(d) and historical data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Impairment of MUN due to eutrophication[1] (nitrogen and phosphorus)	–[1]	✓	2010 303(d) and historical, current monitoring data and public input	–	✓	Dry	Yes
San Dieguito River Below Lake Hodges	San Dieguito River	Potential impairment of REC-1 due *Enterococcus*	✓	✓	2010 303(d), historical and current monitoring data, and Bacteria TMDL at Shoreline	–	✓	Wet, Dry	Yes
		Potential impairment of REC-1 due to fecal coliform	✓	✓	2010 303(d), historical monitoring data, and Bacteria TMDL at Shoreline	✓	✓	Wet, Dry	Yes
		Impairment of WARM due to toxicity	✓	✓	2010 303(d) and historical and current monitoring data	✓	✓	Wet, Dry	Yes
		Impairment of WARM conditions due to eutrophication (ammonia)	–	✓	2010 303(d) and public input	–	–	–	No; No MS4 data, and based on best professional judgment MS4 impacts on eutrophic conditions are not quantifiable.
		Impairment of WARM due to eutrophication (nitrogen)	–	✓	2010 303(d) and public input	–	✓	Dry	Yes
		Impairment of WARM due to TDS	–	✓	2010 303(d) and historical and current monitoring data	–	✓	–	Yes
	Pacific Ocean Shoreline at San Dieguito Lagoon Mouth at San Dieguito River Beach[2]	Impairment of SHELL due to total coliform	✓	✓	2010 303(d)	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Potential impairment of REC-1 due to indicator bacteria (*Enterococcus,* fecal coliform, and total coliform)	✓	✓	Bacteria TMDL	–	–	Wet, Dry	Yes

1. Only listed as a dry weather condition based on best professional judgment that wet weather impacts are not quantifiable.
2. Fletcher outfall, upstream of these waterbodies, has a low flow diverter that could potentially reduce dry weather discharge.
✓ = Criterion applies to temporal extent. – = Criterion does not apply to temporal extent.

Table F-2
Priority Water Quality Conditions in the San Dieguito River WMA Subwatersheds

Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies					
					RW[1]	MS4[2]	City of Del Mar (DM)	City of Escondido (E)	City of Poway (P)	City of Solana Beach (SB)	City of San Diego (SD)	County of San Diego (CO)
San Dieguito River Above Sutherland Reservoir												
Impairment of MUN in Sutherland Reservoir	Color	Dry, Wet	2010 303(d) listed segment	Urban runoff/storm sewers listed in 2010 303(d) as source	Y	Y	–	–	–	–	–	✓
San Dieguito River Above Lake Hodges												
Potential impairment of WARM in Cloverdale Creek	Eutrophic conditions (phosphorus)	Dry	2010 303(d) listed segment	Urban runoff/storm sewers listed in 2010 303(d) as sources; current and historical receiving water monitoring data for downstream waterbodies; historical subwatershed level outfall monitoring data	Y	Y	–	–	–	–	✓	–
Impairment of AGR in Cloverdale Creek	TDS	Dry	2010 303(d) listed segment	Urban runoff/storm sewers listed in 2010 303(d) as sources; current and historical receiving water monitoring data for downstream waterbodies; historical subwatershed level outfall monitoring data	Y	Y	–	–	–	–	✓	–
Impairment of MUN in Green Valley Creek	Chloride	Dry, Wet	2010 303(d) listed segment	Historical subwatershed level outfall monitoring data; current and historical MS4 outfall monitoring data.	Y	Y	–	–	–	–	✓	–

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies					
					RW[1]	MS4[2]	City of Del Mar (DM)	City of Escondido (E)	City of Poway (P)	City of Solana Beach (SB)	City of San Diego (SD)	County of San Diego (CO)
San Dieguito River Above Lake Hodges												
Impairment of MUN in Green Valley Creek	Sulfates	Dry	2010 303(d) listed segment	Urban runoff/storm sewers and natural sources listed in 2010 303(d) as source; historical SMC receiving water monitoring data (limited); historical subwatershed level outfall monitoring data	Y	Y	–	–	–	–	✓	–
Impairment of MUN in Kit Carson Creek	TDS	Dry	2010 303(d) listed segment	Current and historical receiving water monitoring data for downstream waterbodies; current and historical MS4 outfall monitoring data.	Y	Y	–	✓	–	–	✓	✓
Impairment of MUN in Felicita Creek	TDS	Dry	2010 303(d) listed segment	Urban runoff/storm sewers/agricultural return flows/ flow regulation and modification listed in 2010 303(d) as sources; current and historical receiving water monitoring data for downstream waterbodies; historical subwatershed level outfall monitoring data	Y	Y	–	✓	–	–	–	✓
Potential Impairment of REC-1 Above Lake Hodges	Fecal coliform	Wet	Near NPDES monitoring locations	Current and historical receiving water monitoring data for wet weather; subwatershed level outfall monitoring data for wet weather; Bacteria TMDL	N	Y	–	–	✓	✓	–	✓
	Enterococcus	Dry		Current and historical receiving water for dry weather; subwatershed level outfall monitoring data for dry weather; Bacteria TMDL	N	Y	–	–	✓	✓	–	✓

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies					
					RW[1]	MS4[2]	City of Del Mar (DM)	City of Escondido (E)	City of Poway (P)	City of Solana Beach (SB)	City of San Diego (SD)	County of San Diego (CO)
San Dieguito River Above Lake Hodges												
Impairment of MUN in Lake Hodges	Color	Wet, Dry	2010 303(d) listed segment	Urban runoff/storm sewers listed in 2010 303(d) as source; public input	Y	Y	–	✓	✓	–	✓	✓
	Eutrophic conditions (nitrogen and phosphorus)	Dry	2010 303(d) listed segment	Urban runoff/storm sewers listed in 2010 303(d) as sources; current and historical receiving water monitoring data and historical outfall monitoring data; public input	N	Y	–	✓	✓	–	✓	✓
San Dieguito River Below Lake Hodges												
Potential Impairment of REC-1 in San Dieguito River	Indicator bacteria (*Enterococcus* and fecal coliform)	Wet, Dry	2010 303(d) listed segment and near NPDES monitoring locations (wet weather only)	Urban runoff 2010 303(d) listed as a potential source; current and historical receiving water monitoring data	N	Y	–	✓	✓	–	✓	✓
Impairment of WARM in San Dieguito River	Toxicity	Wet, Dry	2010 303(d) listed segment and near NPDES monitoring locations (wet weather only)	Urban runoff 2010 303(d) listed as a potential source; current and historical receiving water monitoring data for downstream waterbodies	Y[3]	Y[3]	–	✓	✓	–	✓	✓
	TDS	Dry	2010 303(d) listed segment		Y[3]	Y[3]	–	✓	✓	–	✓	✓

Continued on next page

Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies					
					RW[1]	MS4[2]	City of Del Mar (DM)	City of Escondido (E)	City of Poway (P)	City of Solana Beach (SB)	City of San Diego (SD)	County of San Diego (CO)
San Dieguito River Below Lake Hodges												
Impairment of WARM in San Dieguito River	Eutrophic conditions (nitrogen)	Dry	2010 303(d) listed segment	Urban runoff 2010 303(d) listed as a potential source; public input	Y[3]	Y[3]	–	✓	✓	–	✓	✓
Potential Impairment of REC-1 at Pacific Ocean Shoreline	Indicator bacteria (*Enterococcus* and fecal coliform)	Wet over-flow	MS4 discharges	Bacteria TMDL	N	Y	✓	✓	✓	✓	✓	✓
Potential Impairment of REC-1 at Pacific Ocean Shoreline	Indicator bacteria (*Enterococcus* and fecal coliform)	Wet, Dry	Pacific Ocean Shoreline at San Dieguito Lagoon Mouth	Bacteria TMDL	N	N	✓	✓	✓	✓	✓	✓

1. Are there gaps in the RW data used to characterize the priority water quality condition? (Y = yes; N = no).
2. Are there gaps in the MS4 data used to characterize the geographical contribution of the MS4 to priority water quality condition? (Y = yes; N = no).
3. The impact of the MS4 is unknown.

DM = City of Del Mar; E = City of Escondido; P = City of Poway; SB = City of Solana Beach; SD = City of San Diego; CO = County of San Diego

Table F-3
Evaluation of Priority Water Quality Conditions in the San Dieguito River WMA

Sub-watershed	Priority Water Quality Condition[1]	Potential Stressor(s)	(a) Supporting Data Is Sufficient to Characterize the Receiving Water Conditions	(b) Storm Water/ Non-Storm Water Runoff Predominant Source	(c) Controllable by Responsible Agencies[2]	(d) Cannot Be Addressed by Identified Strategies
San Dieguito River Above Lake Sutherland	Impairment of MUN in Sutherland Reservoir	Color	–	–	–	✓
San Dieguito River Above Lake Hodges	Potential impairment of WARM in Cloverdale Creek	Eutrophic conditions (phosphorus)	–	–	–	–
	Impairment of AGR in Cloverdale Creek	Total dissolved solids	–	–	–	–
	Impairment of MUN in Green Valley Creek	Chloride	–	–	–	–
		Sulfates	–	–	–	–
	Impairment of MUN in Kit Carson Creek	Total dissolved solids	–	–	–	–
	Impairment of MUN in Felicita Creek	Total dissolved solids	–	–	–	–
	Potential Impairment of REC-1 Above Lake Hodges[3]	Fecal coliform	✓	–	–	–
		Enterococcus	✓	–	–	–

Continued on next page

Sub-watershed	Priority Water Quality Condition[1]	Potential Stressor(s)	(a) Supporting Data Is Sufficient to Characterize the Receiving Water Conditions	(b) Storm Water/ Non-Storm Water Runoff Predominant Source	(c) Controllable by Responsible Agencies[2]	(d) Cannot Be Addressed by Identified Strategies
San Dieguito River Above Lake Hodges	Impairment of MUN in Lake Hodges	Color	–	–	–	–
		Eutrophic conditions (nitrogen and phosphorus)	✓	–	–	–
San Dieguito River Below Lake Hodges	Potential Impairment of REC-1 (in San Dieguito River)[3]	Indicator bacteria (*Enterococcus* and fecal coliform)	✓	–	–	–
	Impairment of WARM in San Dieguito River	Toxicity	–	–	–	✓
		Total dissolved solids	–	–	–	✓
		Eutrophic conditions (nitrogen)	–	–	–	–

"✓" – The criterion is met for the priority water quality condition.
"—" – The criterion is not met for the priority water quality condition.
1. Priorities associated with a TMDL are considered high priority water quality conditions and are not included in this table
2. The priority water quality condition is considered controllable if two criteria are met: (1) There is a clear link between the MS4 contribution and the receiving water conditions, and (2) The potential strategies that apply to the potential stressor are applicable for the drainage area of the receiving water condition.
3. Bacteria TMDL only applicable at Pacific Ocean Shoreline.

APPENDIX G

Bacterial Conceptual Models and Literature Review

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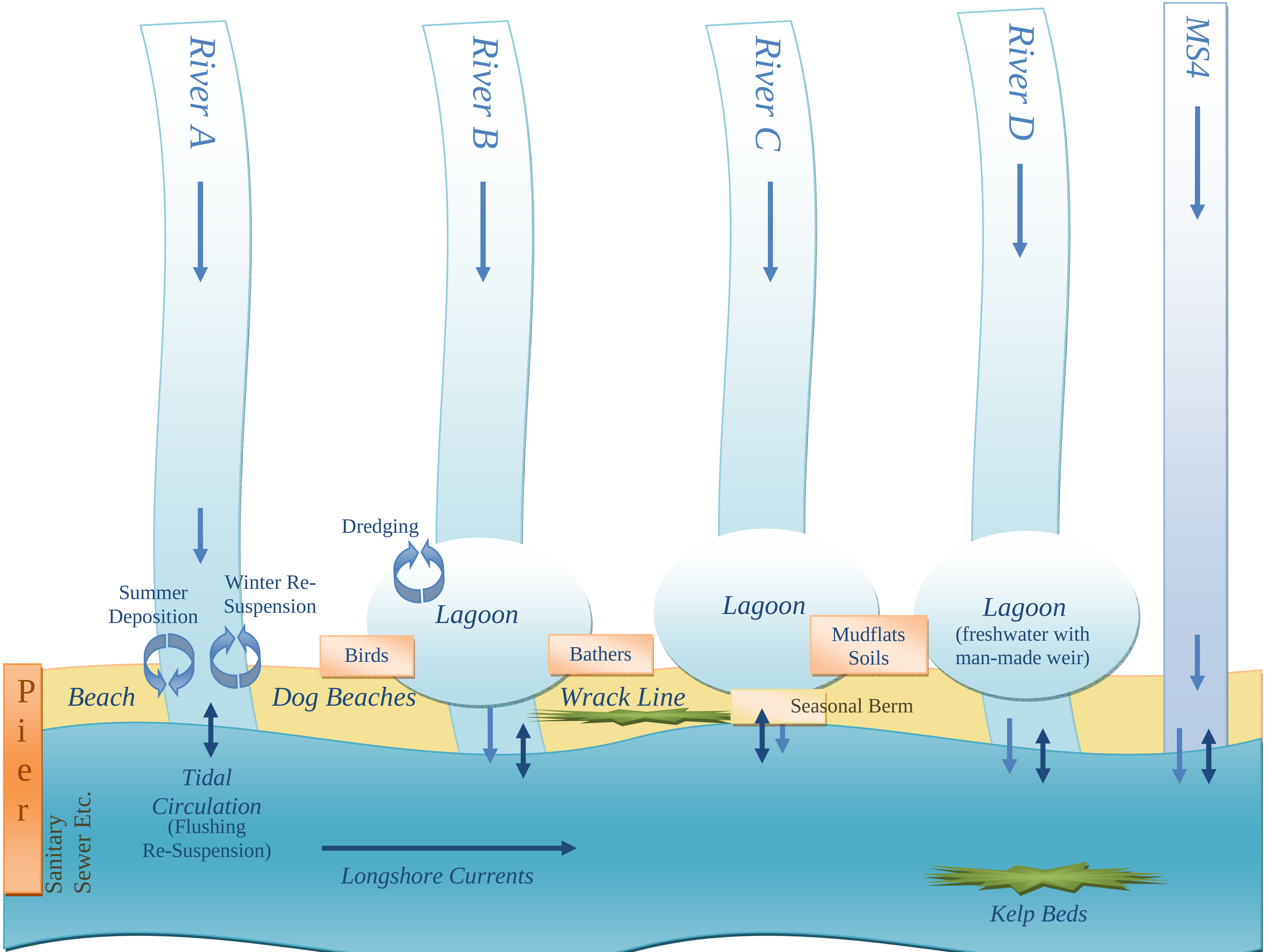
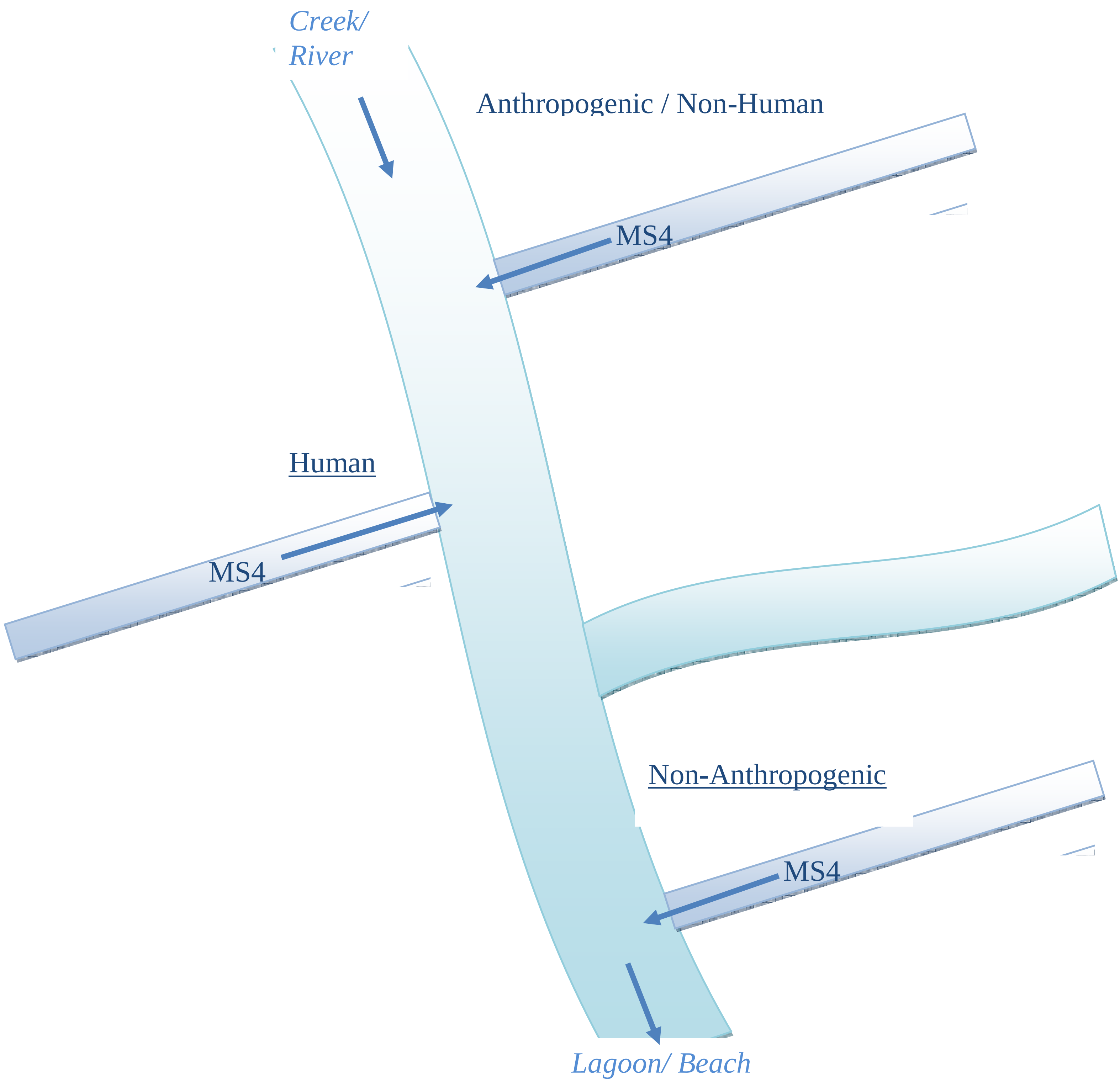
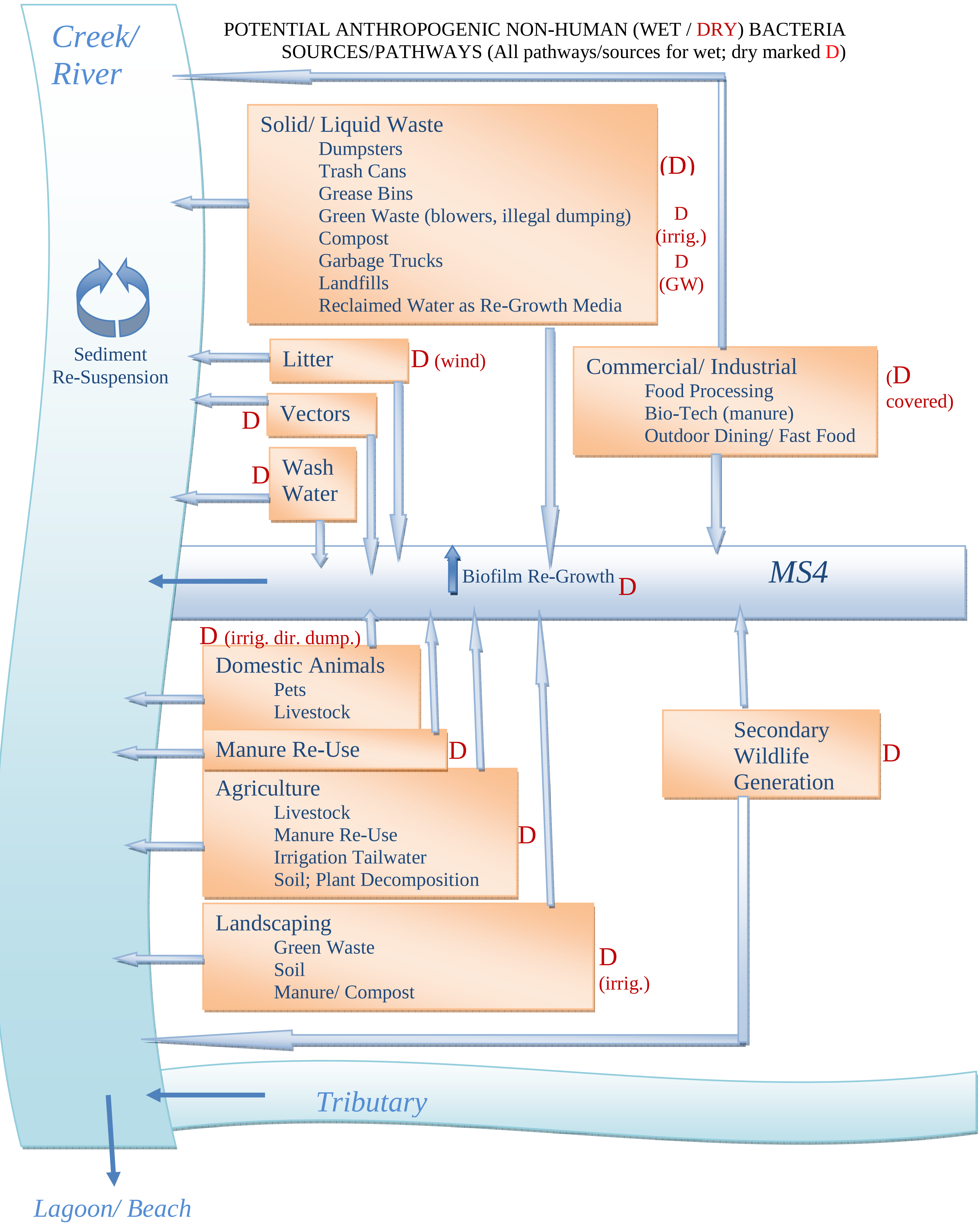
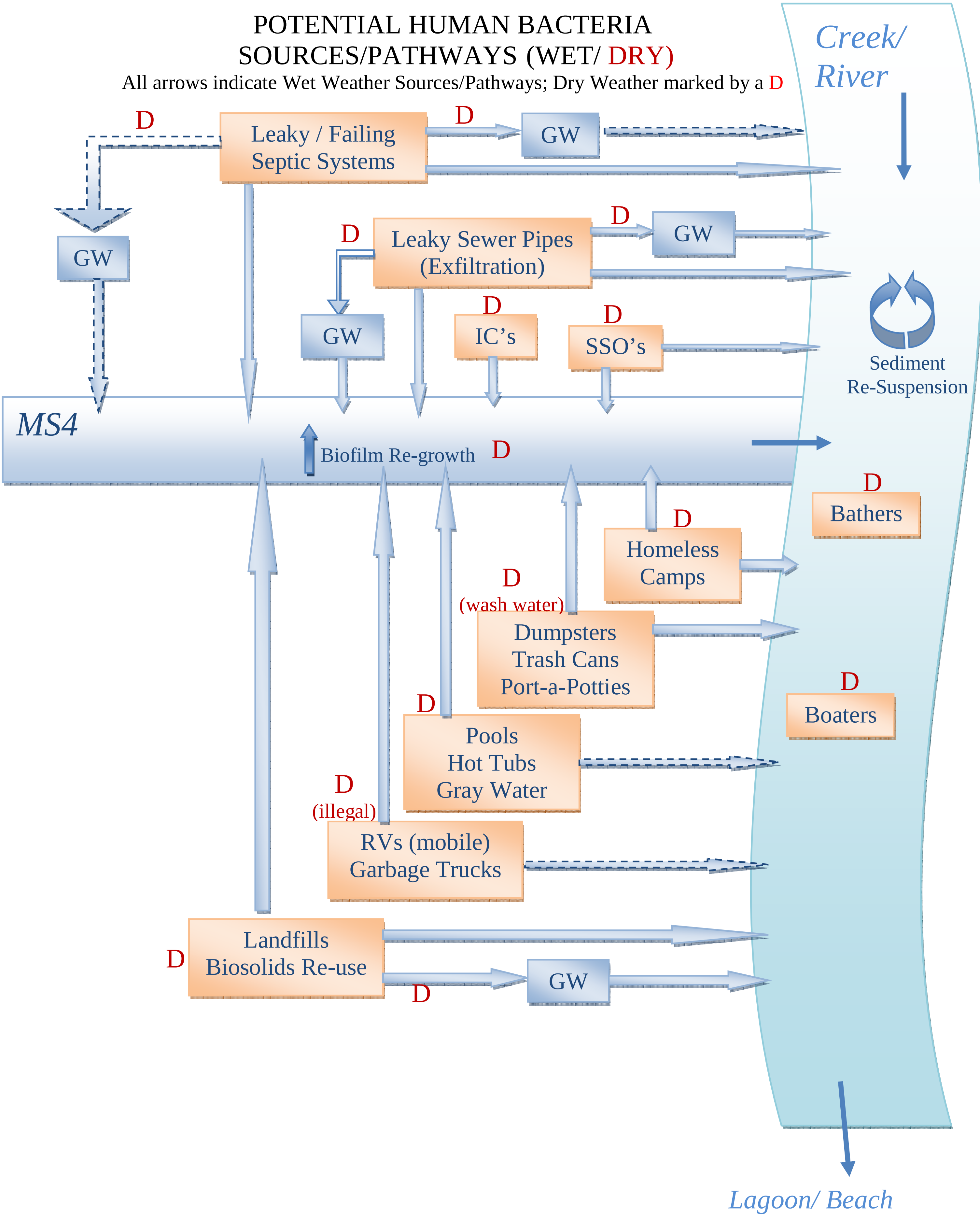


River A
River B
River C
River D
MS4
Dredging
Summer Deposition
Winter Re-Suspension
Lagoon
Lagoon
Lagoon
(freshwater with man-made weir)
Birds
Bathers
Mudflats Soils
Seasonal Berm
Pier
Beach
Dog Beaches
Wrack Line
Tidal Circulation
(Flushing Re-Suspension)
Longshore Currents
Kelp Beds
Sanitary Sewer Etc.

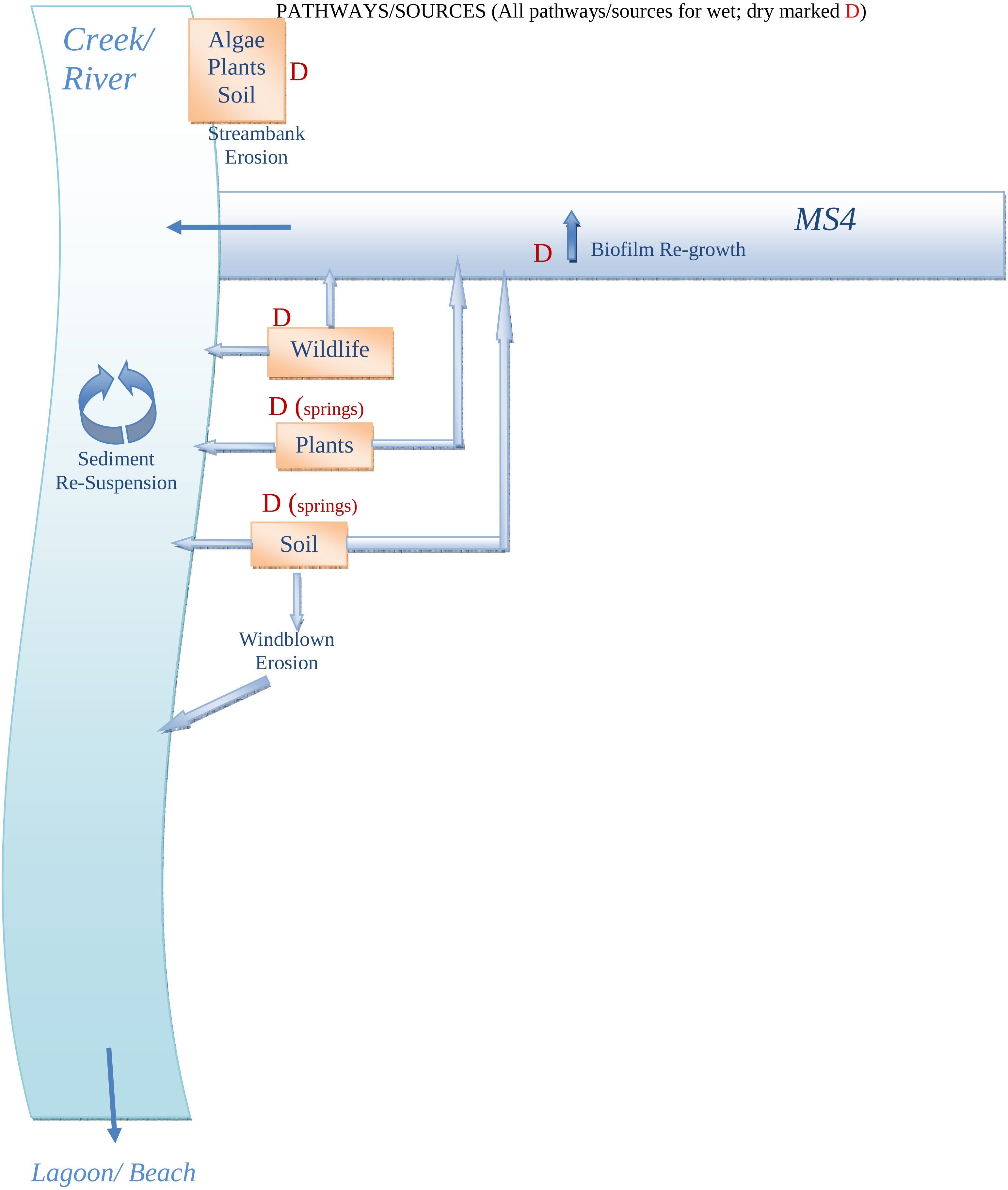
Conceptual Overview of Bacteria Sources




POTENTIAL ANTHROPOGENIC NON-HUMAN (WET / DRY) BACTERIA SOURCES/PATHWAYS (All pathways/sources for wet; dry marked D)
Creek/ River
Sediment Re-Suspension
Solid/ Liquid Waste
Dumpsters
Trash Cans
Grease Bins
Green Waste (blowers, illegal dumping)
Compost
Garbage Trucks
Landfills
Reclaimed Water as Re-Growth Media
(D)
D (irrig.)
D (GW)
Litter
D (wind)
Vectors
D
Wash Water
D
Commercial/ Industrial
Food Processing
Bio-Tech (manure)
Outdoor Dining/ Fast Food
(D covered)
Biofilm Re-Growth
D
MS4
D (irrig. dir. dump.)
Domestic Animals
Pets
Livestock
Manure Re-Use
D
Agriculture
Livestock
Manure Re-Use
Irrigation Tailwater
Soil; Plant Decomposition
D
Landscaping
Green Waste
Soil
Manure/ Compost
D (irrig.)
Secondary Wildlife Generation
D
Tributary
Lagoon/ Beach


POTENTIAL HUMAN BACTERIA
SOURCES/PATHWAYS (WET/ DRY)
All arrows indicate Wet Weather Sources/Pathways; Dry Weather marked by a D
Creek/ River
D
Leaky / Failing Septic Systems
D
GW
GW
D
Leaky Sewer Pipes (Exfiltration)
D
GW
GW
D
IC's
D
SSO's
Sediment Re-Suspension
MS4
Biofilm Re-growth
D
D
Bathers
D
Homeless Camps
D
(wash water)
Dumpsters
Trash Cans
Port-a-Potties
D
Boaters
D
Pools
Hot Tubs
Gray Water
D
(illegal)
RVs (mobile)
Garbage Trucks
D
Landfills
Biosolids Re-use
D
GW
Lagoon/ Beach

POTENTIAL NON-ANTHROPOGENIC WET/ DRY BACTERIA PATHWAYS/SOURCES (All pathways/sources for wet; dry marked D)



DRAFT TECHNICAL MEMORANDUM

Summary of Literature Review, Bacteria Source Identification

March 12, 2012

Prepared by: Armand Ruby Consulting in Association with AMEC

This Technical Memorandum summarizes work performed under Task 2, Literature Search and Data Review, for the County of San Diego Bacterial Indicators Source Identification Services Project. The work was overseen by a workgroup of San Diego County Stormwater Copermittee representatives, and included communication with scientists who have expertise in bacteria source tracking and identification. The literature review focused on identifying and summarizing studies that quantify sources and sinks for bacterial constituents in urban watersheds, and was international in scope.

The work products delivered for this task include this technical memorandum, a separate spreadsheet summary of each study/report reviewed, and a compilation of reviewed studies/reports on the AMEC ftp site:
ftp://ftp.mactec.com/Incoming/Copermittee%20Bact%20Lit%20Review/

The entries in this memorandum are ordered alphabetically by last name of primary author. Each entry begins with the study number (for cross-referencing back to the spreadsheet matrix), followed by the study title. Web links are provided when available.

A number of studies were found that contained information on indicator bacteria but did not include specific information related to source identification within urban watersheds. These studies are summarized as NSC (Not Source Characterization) studies, beginning on p. 53.

The “Bacteria Source ID Lit Review Matrix” Excel workbook contains the following worksheets:

- The “Source ID Studies Summary Table” worksheet contains summaries of all studies reviewed and found to have useful information on bacteria sources; for each of these studies, any identified sources are indicated as Probably, Potential, Low or Suspected (see “Legend” worksheet for definitions)
- The “# Citations by Source” worksheet contains a tally of the numbers of studies with identified information on each source type
- The “Sources Summary Table” worksheet contains condensed summaries of the studies that have information on each particular source type
- The “Data Summary Table” worksheet contains brief summaries of study data (this is a work in progress)
- The “NSC Studies” worksheet provides summaries of the NSC (Not Source Characterization) studies

56 - Human and bovine adenoviruses for the detection of source-specific fecal pollution in coastal waters in Australia
Warish Ahmed, A. Goonetilleke, and T. Gardner
http://eprints.qut.edu.au/37690/1/Human_and_bovine_adenoviruses_for_the_detection_of_source-specific_fecal_pollution_in_coastal_waters_in_Australia.pdf
Purpose - To enhance the scientific foundation for preemptive public health warnings, examine the relationship between rainfall and beach indicator bacteria concentrations using five years of fecal coliform data taken daily at 20 sites in southern California.

Results - There was a clear relationship between the incidence of rainfall and reduction in beach bacterial water quality in Los Angeles County. Bacterial concentrations remained elevated for five days following a storm, although they generally returned to levels below state water quality standards within three days. The length of the antecedent dry period had a minimal effect on this relationship, probably reflecting a quickly developing equilibrium between the decay of older fecal material and the introduction of new fecal material to the landscape.

Sources:
Probable –Septic (human waste), bovine (domestic animals), animal farms (agriculture),
Potential -
Possible -

31 - Evaluation of Multiple Sewage-Associated Bacteroides PCR Markers for Sewage Pollution Tracking
Warish Ahmed, A. Goonetilleke, D. Powell, and T. Gardner
http://eprints.qut.edu.au/29217/1/c29217.pdf
Purpose - The host specificity of the five published sewage-associated Bacteroides markers (i.e., HF183, BacHum, HuBac, BacH and Human-Bac) was evaluated in Southeast Queensland, Australia by testing fecal DNA samples (n = 186) from 11 animal species including human fecal samples collected via influent to a sewage treatment plant (STP).

Results - For the 5 sewage-associated markers tested in this study, the HF183 marker performed better than others. This marker showed 99% specificity to distinguish between the sources of human and animal fecal pollution. The performance of the five markers in terms of specificity was HF183 > BacHum > BacH > Human-Bac > HuBac.

78 - Detection and source identification of faecal pollution in non-sewered catchment by means of molecular markers host-specific
Warish Ahmed, D. Powell, A. Goonetilleke, and T. Gardner
http://s3.amazonaws.com/publicationslist.org/data/w.ahmed/ref-23/WST%20Article.pdf
Purpose - To validate the previously published host-specific PCR markers (i.e. HF183, HF134, CF128, BacCan and esp) for the detection of sources of faecal pollution by testing a large number of faecal samples from 13 host groups in Southeast Queensland, Australia.

Results - All 197 faecal samples (100%) from the 13 host groups were positive for general Bacteroides. Of the 42 (i.e. 30 sewage and 12 septic samples) sewage/septic samples tested, all were positive for the human-specific HF183 and HF134 Bacteroides markers. The HF183 marker could not be detected in any faecal samples from animal host groups suggesting that the suitability of this marker to detect human faecal pollution. In contrast, the HF134 marker was detected in 7 (35%) samples from dogs. The presence of this marker in dogs could be due to the transfer of faecal bacteria between human and their companion pets (Dick et al. 2005).

79 - Evaluation of Bacteroides markers for the detection of human faecal pollution
Warish Ahmed, J. Stewart, D. Powell, and T. Gardner
http://onlinelibrary.wiley.com/doi/10.1111/j.1472-765X.2007.02287.x/pdf
Purpose - Evaluating the specificity and sensitivity of human-specific HF183 and HF134 Bacteroides markers in various host groups and their utility to detect human faecal pollution in storm water samples collected from non-sewered catchments in Southeast Queensland, Australia.

Results - The specificity and sensitivity of the HF183 and HF134 Bacteroides markers was evaluated by testing 207 faecal samples from 13 host groups, including 52 samples from human sources (via sewage and septic tanks). Polymerase chain reaction analysis of these samples revealed the presence ⁄ absence of HF183 and HF134 across these host groups, demonstrating their suitability for distinguishing between human and animal faecal pollution. The HF183 marker was found to be more reliable than that of HF134, which was also found in dogs.

35 - Quantitative PCR assay of sewage-associated Bacteroides markers to assess sewage pollution in an urban lake in Dhaka, Bangladesh
Warish Ahmed, R. Yusuf, I. Hasan, A. Goonetilleke, and T. Gardner
http://eprints.qut.edu.au/37689/1/Quantitative_PCR_assay_of_sewage-associated_Bacteroides_markers_to_assess_sewage_pollution_in_an_urban_lake_in_Dhaka,_Bangladesh.pdf
Purpose - To assess the magnitude of sewage pollution in an urban lake in Dhaka, Bangladesh 34 by using Quantitative PCR (qPCR) of sewage-associated Bacteroides HF183 markers.

Results – From the 20 water samples tested, 14 (70%) and 7 (35%) were PCR positive for the HF183 and CF128 markers, respectively. The high numbers of enterococci and the HF183 markers indicate sewage pollution.

Sources:
Probable - Slum-like establishments (human waste), MS4 Infrastructure (human waste),
Potential -
Possible – Dogs and cows

139 - Coastal water quality impact of storm water runoff from an urban watershed in Southern California

Jong Ho Ahn, S.B. Grant, C.Q. Surbeck, P.M. DiGiacomo, N.P. Nezlin, and S. Jiang
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/528_B03_WQ_Appendix_I.pdf
Purpose - Assess the coastal water quality impact of storm water runoff from the Santa Ana River, which drains a large urban watershed located in southern California. This is the first wet weather study to examine the linkage between water quality in the surf zone -- where routine monitoring samples are collected and most human exposure occurs -- and water quality offshore of the surf zone.

Results - Storm water runoff from the Santa Ana River negatively impacts coastal water quality, both in the surf zone and offshore. However, the extent of this impact, and its human health significance, is influenced by numerous factors, including prevailing ocean currents, within-plume processing of particles and pathogens, and the timing, magnitude and nature of runoff discharged from river outlets over the course of a storm.

Sources:
Probable - Slum-like establishments (human waste), MS4 Infrastructure (human waste),
Potential -
Possible – Dogs and cows

17 - Lower San Luis Rey River Bacteria Source Identification Study

AMEC, UNC, City of Oceanside, SCCWRP, and USC
Purpose - The goal of the Project was to identify hot spots of fecal indicator bacteria; identify potential sources and prioritize those sources and locations for future bacteria reductions through management measures.

Results - There is evidence of the human-related bacterial sources throughout the river system. Sediment in the river mouth is a contributing source of fecal bacteria to the water column when the river mouth is closed to tidal exchange. The resident gull population was a probable source of fecal bacteria in the river mouth. Additional, monitoring is needed to identify human sources.

Sources:
Probable - Non-specific source (human waste),
Potential–Gulls (secondary wildlife), soil, sediment and sand (seasonal),
Possible - Sewage infrastructure, mobile sources (human waste), domestic animals

43 - Monitoring and Mitigation to Address Fecal Pathogen Pollution along California Coast

Applied Marine Sciences, Inc., University of California Davis, California Department of Fish and Game, and Marine Wildlife Veterinary Care and Research Center
Purpose - The goals of this research program were to use both laboratory and field approaches to investigate issues related to water quality monitoring and mitigation of fecal pathogen pollution along the central California coast.

Results - The universal Bacteroidales marker was detected in all water samples (100%). The human Bacteroidales marker was detected in 37% of samples, while the cow (8%) and dog (6%) bacteroidales markers were detected in less than 10% of samples. Overall, Bacteroidales concentrations ranged from 87-1.3 million gc/mL for universal markers, 45-17,268 gc/mL for human markers, 3-92 gc/mL for cow markers, and 12-575 gc/mL for dog markers.

Sources:
Probable – Non-specific source (human waste),
Potential - Dogs and livestock,
Possible –

68 - Little Sac River Watershed Bacterial Source Tracking Analysis
Dr. Claire Baffaut, Dr. C.A. Carson, and W. Rogers
https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/3029/LittleSacBacterial.pdf?sequence=1
Purpose - To identify the sources of bacteria found in the Little Sac River using rep-PCR analyses of fecal material.

Results - The data show that the highest fecal coliform loads come from unknown sources, geese, and human. Data show that sources differ by season but the magnitude of the contamination is not significantly affected by season.

Sources:
Probable – Wastewater treatment plant, Geese (non-specific source)
Potential – Cattle and horses
Possible – Septic (sewage infrastructure)

117 - SOURCES OF POLLUTANTS IN WISCONSIN STORMWATER
R.T. Bannerman, D.W. Owens, R.B. Dodds, and N.J. Hornewer
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.176.2404&rep=rep1&type=pdf
Purpose - Identification of critical source areas (streets, roads, parking lots, etc.) could reduce the amount of area needing best-management practices in two areas of Madison, WI. Targeting best-management practices to 14% of the residential area and 40% of the industrial area could significantly reduce contaminant loads by up to 75%.

Results - Streets will probably be a critical source area in every land use. The majority of the runoff loads for many contaminants may be from streets in residential and commercial land uses. Parking lots are probably another critical source for commercial and industrial land uses. About 77% of the area in the commercial land use would have to be managed to control at least 75% of the loads for all contaminants except fecal coliform bacteria.

Sources:
Probable – Sewer outfall, Street runoff (residential, commercial and industrial)

Potential – Cattle and horses
Possible – Septic (sewage infrastructure)

82 - Tiered Approach for Identification of a Human Fecal Pollution Source at a Recreational Beach: Case Study at Avalon Bay, Catalina Island, California

Alexandria B. Boehm, J.A. Fuhrman, R.D. Morse, and S.B. Grant

http://dornsife.usc.edu/labs/fuhrman/Documents/Publications/Tiered%20Approach.pdf

Purpose - In this study, a three-tiered approach is used to identify human and nonhuman sources of FIB in Avalon Bay, a popular resort community on Catalina Island in southern California.

Results - Most of the FIB contamination along the shoreline of the City of Avalon is due to sources inside the bay and, in particular, from the land side of the beach. During the 24-h survey, the most contaminated shoreline sites exhibited a semi-diurnal FIB pattern in which the concentrations increased during ebbing tides. The multiple instances of positive HF and HV assay results at shoreline stations indicate that human fecal contamination exists in Avalon Bay. The nuisance runoff and bird feces had the highest levels of FIB with TC, EC, and ENT consistently near or above the upper limit of detection for water samples 24 192 MPN/100 mL. With the exception of sample R101, pipe discharges from underneath the pier and wharf and the cooling water boat discharge had relatively low levels of FIB. Sample R101 was take from a broken pipe carrying gray water underneath the wharf and had TC and EC levels above our detection limit of 24 192 MPN/100 mL and ENT levels of 10 462 MPN/100 mL, which is 100 times higher than the CDHS single-sample standard. City officials repaired this pipe in early October. Subsurface water collected from within the five trenches had sporadically high levels of FIB.

Sources:
Probable – Non-specific source (urban land use; human waste), MS4 Infrastructure (dry weather runoff; human waste), birds (secondary wildlife), reclaimed water (leaking graywater pipe)
Potential –
Possible – Commercial/Industrial (boat cooling water, pier, and wharf discharges from pipes)

153 - Cross-Shelf Transport at Huntington Beach Implications for the Fate of Sewage Discharged through an Offshore Ocean Outfall

Alexandria B. Boehm, B.F. Sanders, and C.D. Winant

http://www-ccs.ucsd.edu/~cdw/mypubs/109.pdf

Purpose - Evaluate the potential for internal tides to transport wastewater effluent from the Orange County Sanitation District (OCSD) ocean outfall toward Huntington Beach.

Results - On the basis of these analyses, it remains unclear whether OCSD effluent impairs surf-zone water quality. However, OCSD plume cannot be ruled out as a contributor to poor bathing-water quality at Huntington Beach.

131 - Source Tracking in Lake Darling Watershed
Janice Boekhoff
http://www.igsb.uiowa.edu/wqm/Publications/Reports/LakeDarlingFinalReport.pdf
Purpose - Determine the source of fecal contamination in Lake Darling and the surrounding watershed.

Results - E. coli bacteria from most of the water samples at Lake Darling have been identified by DNA ribotyping as coming from unknown sources of fecal contamination (75% of the water samples had bacteria from unknown sources using the WHU library). More unknown source classifications than known sources suggested the E. coli isolate library was either not large enough or was not representative of all of the sources in the watershed.

Sources:
Probable – Secondary wildlife (cattle and swine), Wildlife (unknown)
Potential –
Possible – Commercial/Industrial (boat cooling water, pier, and wharf discharges from pipes)

83 - Detection of Genetic Markers of Fecal Indicator Bacteria in Lake Michigan and Determination of Their Relationship to Escherichia coli Densities Using Standard Microbiological Methods
Patricia A. Bower, C.O. Scopel, E.T. Jensen, M.M. Depas, and S.L. McLellan
http://aem.asm.org/content/71/12/8305.full.pdf+html
Purpose - Lake Michigan surface waters impacted by fecal pollution were assessed to determine the occurrence of genetic markers for Bacteroides and Escherichia coli.

Results - Human-specific Bacteroides spp. were found at three of the nine beach sites tested. Human-specific Bacteroides genetic marker is a sensitive measure of sewage contamination. Sanitary sewage overflow samples taken in the suburban part of the watershed showed the presence of cow-specific genetic marker, since the cow-specific primers do not differentiate between types of ruminants, i.e., elk, deer, and cows.

Sources:
Probable – CSO and SSO (Sewage infrastructure; human waste)
Potential – Sanitary sewer infiltration into the storm drain (Sewage infrastructure; human waste), Ruminant (wildlife; non-anthropogenic)
Possible – Sanitary sewer infiltration into the storm drain (Sewage infrastructure; human waste)

27 – Antibiotic Resistance Analysis of Fecal Coliforms to Determine Fecal Pollution Sources in a Mixed-Use Watershed
Brian S. Burnes
http://www.springerlink.com/content/q3213338g1578x88/fulltext.pdf

Purpose - Antibiotic resistance analysis was performed on fecal coliform (FC) bacteria from a mixed-use watershed to determine the source, human or nonhuman, of fecal coliform contamination.

Results - Human sources contribute a majority (>50%) of the baseflow FC isolates found in the watershed in urbanized areas. Chicken and livestock sources are responsible for the majority of the baseflow FC isolates found in the rural reaches of the watershed. Stormwater introduces FC isolates from domestic (~16%) and wild (~21%) sources throughout the watershed and varying amounts (up to 60%) from chicken and livestock sources. These results suggest that antibiotic resistance patterns of FC may be used to determine sources of fecal contamination and aid in the direction of water quality improvement.

Sources:
Probable – Urbanized watershed (human waste), cows and chickens (rural watershed)
Potential –Stormwater runoff,
Possible –

13 - Results from a Microbial Source-Tracking Study at Villa Angela Beach, Cleveland, Ohio 2007
Rebecca N. Bushon, E.A. Stelzer, and D.M. Stoeckel
Purpose - The overall goal of the study was to provide NEORSD with source-tracking information to aid in their understanding of elevated bacterial concentrations at Villa Angela Beach in Cleveland Ohio. To understand these elevation concentrations, 13 source samples (influent/effluent to sewage treatment plant, waterfowl feces from beach area, combined sewer overflow, stormwater outfall) and 33 beach-area water and sand samples were analyzed for E coli and 3 Bacteroides DNA markers

Results - Therefore, Btheta does not appear to be a useful human-associated marker for this beach area. In the Lake, human source is not a likely contributor of fecal bacteria, however, the gulls are a probable source. In Euclid Creek, there were strong signals of human sources on two occasions and gulls were not present. The sand did not have human sources present and gull sources were present in low concentrations.

Sources:
Probable -
Potential - Combined sewer overflow, influent/effluent to sewage treatment plant, waterfowl feces from beach area,
Possible -

85 - Population structure, persistence, and seasonality of autochthonous Escherichia coli in temperate, coastal forest soil from a Great Lakes watershed
Muruleedhara N. Byappanahalli, R.L. Whitman, D.A. Shively, M.J. Sadowsky, and S. Ishii
http://www.glsc.usgs.gov/_files/publications/population.pdf

Purpose - In this study, undisturbed, forest soils within six randomly selected 0.5 m exclosure plots (covered by netting of 2.3 mm mesh size) were monitored from March to October 2003 for E. coli in order to describe its numerical and population characteristics.

Results - In this study, soil was found as a potential habitat for the persistent, perhaps resident, E. coli populations in temperate conditions. While our studies showed that E. coli can occur in temperate forest soils, albeit at low densities, it also had the ability to persist for extended periods in these habitats, suggesting that it is not a transient organism in soil but perhaps part of the natural microflora. Even if this is not the case, its population resiliency suggests that soil-borne E. coli should be treated as background concentration in source and impact evaluation investigations.

Sources:
Probable – Soil/Sediment/Sand (non-anthropogenic)
Potential –
Possible – Gull, deer, geese, terns (wrackline; non-anthropogenic)

84 - Ubiquity and Persistence of Escherichia coli in a Midwestern Coastal Stream
Muruleedhara Byappanahalli, M. Fowler, D. Shively, and R. Whitman.
http://aem.asm.org/content/69/8/4549.full.pdf+html
Purpose - Dunes Creek, a small Lake Michigan coastal stream that drains sandy aquifers and wetlands of Indiana Dunes, has chronically elevated Escherichia coli levels along the bathing beach near its outfall. This study sought to understand the sources of chronically elevated Escherichia coli levels along the bathing beach near its outfall in Dunes Creek's central branch.

Results - Water samples analyzed during the 1999 and 2000 monitoring seasons clearly demonstrated that E. coli concentrations in Dunes Creek were significantly correlated with the park's beach water. Dunes Creek empties directly onto the state park's only swimming beach, indicating that the creek directly impacts bathing water quality. E. coli is common within the stream basin, especially in submerged, margin, and wetted bank sediments, with numbers rapidly decreasing landward beyond the banks. The relationship between E. coli concentration and stream order suggests that excessive ditching and, consequently, non-point source input via sediment transport are responsible for elevated E. coli density in the watershed.

Sources:
Probable – Soil/Sediment/Sand (non-anthropogenic)
Potential –
Possible – Non-specific source (groundwater; non-anthropogenic)

3 - Pismo Beach Fecal Contamination Source Identification Study; Final Report. Aug. 12, 2010
CAL POLY and City of Pismo Beach
http://www.coastalrcd.org/images/cms/files/PismoFinalReport-v1_4%5B1%5D.pdf

Purpose - To identify biological sources of fecal contamination. Primary sources found were bird fecal contamination.

Results - The data collected in this study clearly shows the main source of fecal contamination on the beach is bird droppings near the pier. Nearly 40% of the E. coli strains collected in this study matched bird fecal sources, and E coli strains with a pigeon-specific fingerprint were collected. In addition, measuring the time since a tide last washed the part of the beach being sampled was an excellent predictor of FIB count, indicating that deposition of fecal matter on the beach itself was a predominate contamination mode.

Sources:
Probable - Bathers, dogs, pigeons (secondary wildlife)
Potential - Cows
Possible -

86 - Sourcing faecal pollution from onsite wastewater treatment systems in surface waters using antibiotic resistance analysis
S. Carroll, M. Hargreaves, and A. Goonetilleke
http://eprints.qut.edu.au/4018/1/4018.pdf
Purpose - To identify the sources of faecal contamination in investigated surface waters and to determine the significance of onsite wastewater treatment systems (OWTS) as a major contributor to faecal contamination.

Results - Antibiotic resistance patterns (ARP) were established for a library of 717 known Escherichia coli source isolates obtained from human, domesticated animals, livestock and wild sources. The resulting ARP DA indicated that a majority of the faecal contamination in more rural areas was nonhuman; however, the percentage of human isolates increased significantly in urbanized areas using OWTS for wastewater treatment.

Sources:
Probable – Sewage infrastructure (onsite wastewater treatment systems; human waste)
Potential –
Possible –

28 - Faecal pollution source identification in an urbanising catchment using antibiotic resistance profiling, discriminant analysis and partial least squares regression
Steven P. Carroll, L. Dawes, L., M. Hargreaves, and A. Goonetilleke
http://eprints.qut.edu.au/19108/1/c19108.pdf
Purpose - Antibiotic Resistance Patterns (ARP) were established for a library of 1005 known E. coli source isolates obtained from human and non-human (domesticated animals, livestock and wild) sources in an urbanising catchment in Queensland State, Australia. Discriminant Analysis (DA) was used to differentiate between the ARP of source isolates and to identify the sources of faecal contamination.

Results - The resulting ARP (Antibiotic Resistance Patterns) DA (Discriminant Analysis) indicated that a majority of the faecal contamination in the rural areas was non-human. However, the percentage of human isolates increased significantly in urbanised areas using onsite systems for wastewater treatment. The PLS regression was able to develop predictive models which indicated a high correlation of human source isolates from the urban area.

Sources:
Probable - Urbanized watershed (human waste), agriculture, other (land use)
Potential –
Possible -

47 - Middle Santa Ana River Bacterial Indicator TMDL Data Analysis Report
CDM and Risk Sciences
Purpose - The primary goal of this study was "to develop an investigative strategy at the highest priority sites, including site-specific or subwatershed-specific activities."

Results – Analysis showed significant differences in the frequency with which molecular markers for humans, dogs, and cattle were detected at the various source evaluation sites. The sites with highest frequency of detection of host-specific markers included the Human marker at Box Springs Channel and Chris Basin; Bovine marker at Anza Drain, Cypress Channel and San Antonio Channel; and Domestic canine marker at Chris Basin, County Line Channel and Day Creek. Where the universal marker was measured, it was a quantified at levels much higher than the other measured markers, indicating the presence of many other sources of bacteria, e.g. birds, rodents, small mammals and reptiles. Preliminary review of land use data indicates that bacterial concentrations are positively correlated with degree of urban development and negatively correlated with the proportion of agricultural acreage and open space in the area.

Sources:
Probable – Non-specific source (human waste; 1 of 13 sites), dogs(1 of 13 sites) and cows(3 of 13 sites), commercial/industrial (anthropogenic non-human source), residential, commercial, and industrial (land use)
Potential -
Possible – Agriculture (anthropogenic non-human source),natural land use (non-anthropogenic) natural and agricultural (land use)

127 - Densities of fecal indicator bacteria in tidal waters of the Ballona Wetlands, Los Angeles County, California
John. H. Dorsey
http://www.freepatentsonline.com/article/Bulletin-Southern-California-Academy-Sciences/151712972.html
Purpose - Densities of fecal indicator bacteria (FIB) represented by total coliforms, E. coil and enterococci were measured within tidal channels of the Ballona Wetlands (Los Angeles County) to see of the wetlands act as a sink or source for these bacteria and to measure increases in FIB densities during wet weather.

Results - Results suggest that the wetlands may act as a sink in that FIB densities tended to be greater during flood flows into the wetlands, but less in water draining out of the system during ebb flows. However, this condition was not consistently met, especially at stations farthest from the tide gates. These sites could be reflecting increased FIB densities through regrowth within sediments and other unidentified sources.

Sources:
Probable –Storm drains
Potential –
Possible -

181 - Reduction of fecal indicator bacteria (FIB) in the Ballona Wetlands saltwater marsh (Los Angeles County, California, USA) with implications for restoration actions
John H. Dorsey, P.M. Carter, S. Bergquist and R. Sagarin
http://www.sciencedirect.com/science/article/pii/S004313541000388X/
Purpose - Determine FIB tidal dynamics within the wetland

Results - The wetlands act as both a source and sink for FIB depending on tidal conditions and exposure to sunlight. Future restoration actions would result in a tradeoff – increased tidal channels offer a greater surface area for FIB inactivation, but also would result in a greater volume of FIB-contaminated re-suspended sediments carried out of the wetlands on stronger ebb flows. As levels of FIB in Ballona Creek and Estuary diminish through recently established regulatory actions, the wetlands could shift into a greater sink for FIB.

119 - FECAL COLIFORM AND STREPTOCOCCUS CONCENTRATIONS IN RUNOFF FROM GRAZED PASTURES IN NORTHWEST ARKANSAS
D. R. Edwards, M.S. Coyne, P.F. Vendrell, T.C. Daniel, P.A. Moore, Jr., and J.F. Murdoch
http://www.pcwp.tamu.edu/docs/lshs/end-notes/Fecal%20Coliform%20and%20Streptococcus%20Concen-0982758667/Fecal%20Coliform%20and%20Streptococcus%20Concentrations%20in%20Runoff%20from%20Grazed%20Pastures%20and%20Northwest%20Arkansas.pdf
Purpose - Assess the effects of grazing, time of year, and runoff amounts on FC and FS concentrations and to evaluate whether FCIFS concentration ratios are consistent with earlier values reported as characteristic of animal sources.

Results - In general, FC and FS concentrations were not directly related to either treatment with animal manure or presence of grazing cattle. Ratios of FC to FS concentrations varied widely ranging from almost zero to more than 100. These data confirm earlier findings that FC/FS ratios are not a reliable indicator of the source of FC and FS in the runoff.

147 - FECAL-INDICATOR BACTERIA IN STREAMS ALONG A GRADIENT OF RESIDENTIAL DEVELOPMENT
Steven A. Frenzel and C.S. Couvillion
http://lshs.tamu.edu/docs/lshs/end-notes/fecal%20indicator%20bacteria%20in%20streams%20along%20a%20gradient%20of%20resid-3692103194/fecal%20indicator%20bacteria%20in%20streams%20along%20a%20gradient%20of%20residential%20development.pdf
Purpose - In order to adopt EPA water-quality standards for concentrations of Escherichia coli (E. coli) or enterococci, and study to determine the effects of urbanization on water quality.

Results - Areas served by sewer systems had significantly higher fecal-indicator bacteria concentrations than did areas served by septic systems. The areas served by sewer systems also had storm drains that discharged directly to the streams, whereas storm sewers were not present in the areas served by septic systems. Fecal-indicator bacteria concentrations were highly variable over a two-day period of stable streamflow, which may have implications for testing of compliance to water-quality standards.

120 - Soil: the environmental source of Escherichia coli and Enterococci in Guam's streams
R. Fujioka, C. Sian-Denton, M. Borja, J. Castro, and K. Morphew
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.1998.tb05286.x/pdf
Purpose - Test the hypothesis that faecal bacteria are able to establish themselves in the soil environments of tropical islands by conducting a study in Guam, a tropical pacific island with warmer temperatures and higher humidity than Hawaii (covered in a previous study).

Results - Results obtained in Guam were similar to the results obtained in Hawaii and provided convincing evidence that the faecal bacterial indicators selected by USEPA to establish recreational water quality standards are able to colonize the soil environments of warm, humid tropical islands, current hygienic water quality standards which are based on concentrations of faecal indicator bacteria may not be applicable in tropical islands and perhaps other subtropical and tropical countries in the world. In these countries, stream waters can be expected to contain elevated levels of faecal bacteria.

Sources:
Probable - Rainfall
Potential –
Possible -

91 - Use of composite data sets for source-tracking enterococci in the water column and shoreline interstitial waters on Pensacola Beach, Florida
Fred J. Genthner, J.B. James, D.F. Yates, and S.D. Friedman
http://64.9.200.77/lists/beachnet/2005-07/pdf00002.pdf

Purpose - Source identification was performed to better understand risk associated with higher densities of enterococci found in swash zone interstitial water (SZIW) as compared to adjacent bathing water on Pensacola Beach, FL.

Results - This study documents higher densities of enterococci in SZIW than in adjacent bathing waters on Pensacola Beach. Entrapment may partially account for increased bacteria densities, however, biological factors (nutrients, protection from predation) and physical factors (particulate matter, periodic wetting and drying, protection from solar irradiation) may not only allow the enhanced survival of bacteria but may actually provide a growth- promoting environmental niche on the beach.

Sources:
Probable – Seagull (secondary wildlife)
Potential –
Possible **– Non-specific source (human waste)**

46 - Laguna Watershed Study and Water Quality Improvement Feasibility Analysis
Geosyntec and UCSB
Purpose - To evaluate dry weather hydrology, microbiological indicators, bacterial sources and loads, and feasible water quality improvements for the Laguna Channel in Santa Barbara, CA.

Results – Based on the analysis of human-specific Bacteroides DNA, it appears that there is significant input of human fecal waste into some Laguna storm drains and into Laguna Channel. An obvious spatial correlation between measured FIB and Human specific Bacteroides Marker (HBM) concentrations could not be identified; similar trends between indicator species and HBM concentrations were also not observed.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible -

148 - Quantitative Detection of Hepatitis A Virus and Enteroviruses Near the United States-Mexico Border and Correlation with Levels of Fecal Indicator Bacteria
Richard M. Gersberg, M.A. Rose, R. Robles-Sikisaka, and A.K. Dhar
http://publichealth.sdsu.edu/publications/gersberg684.pdf
Purpose - To measure the levels of Hepatitis A virus (HAV) and enteroviruses in coastal waters, and compare to E. coli and enterococci.

Results - HAV and enterovirus were found in 93% of wet weather samples. Inadequate sewage infrastructure in Tijuana, Mexico, also contributes to the high levels found at some sites.

60 - Evaluation of Two Library-Independent Microbial Source Tracking Methods to Identify Sources of Fecal Contamination in French Estuaries
Michele Gourmelon, M.P. Caprais, R. Segura, C. Le Mennec, S. Lozach, J.Y. Piriou, and A. Rince
http://aem.asm.org/content/73/15/4857.full.pdf+html
Purpose - The aim of this study was to optimize and validate the two MST techniques (host-specific 16S rRNA gene markers from Bacteroidales and genotyping of F-specific RNA bacteriophages) on human and animal feces, sewage treatment plant (STP) sludge, wastewater samples, and pig liquid manure (PLM; pig slurry) collected in France. Both techniques were then applied to water samples collected at different times from three estuaries

Results - Humans and animals sources are detected as sources of E. coli and Enterococci contamination in the estuaries based on host-specific Bacteroidales and F-specific bacteriophages

Sources:
Probable – Septic (human waste), livestock (domestic animals), livestock (agriculture), birds (wildlife), birds (secondary wildlife)
Potential -
Possible -

23 - Generation of Enterococci Bacteria in Saltwater Marsh and its impact on the surf zone water quality
Steven B. Grant, B.F. Sanders, A.B. Boehm, A.J. Redman, J.H. Kim, R.D. Mrše, A.K. Chu, M. Gouldin, C.D. McGee, N.A. Gardiner, B.H. Jones, J. Svejkovsky, G.V. Leipzig, and A. Brown
https://www.crops.org/publications/jeq/pdfs/31/4/1300
Purpose - To characterize the sources and transport of Enterococcus in tidally influenced flood control channels and a saltwater marsh.

Results - We find that enterococci bacteria are present at high concentrations in urban runoff, bird feces, marsh sediments, and on marine vegetation. Surprisingly, urban runoff appears to have relatively little impact on surf zone water quality because of the long time required for this water to travel from its source to the ocean. On the other hand, enterococci bacteria generated in a tidal saltwater marsh located near the beach significantly impacts surf zone water quality.

Sources:
Probable – Marsh (non-anthropogenic; non-specific source), wildlife (marsh avian), marsh sediment, soil/sediment/sand
Potential –
Possible –

92 - Antibiotic Resistance Profiles to Determine Sources of Fecal Contamination in a Rural Virginia Watershed
Alexandria K. Graves, C. Hagedorn, A. Teetor, M. Mahal, A.M. Booth, and R.B. Reneau
https://www.crops.org/publications/jeq/pdfs/31/4/1300

Purpose - Antibiotic resistance analysis (ARA) was used to determine if enterococci of human origin were present in a stream (Spout Run) that passes through a rural non-sewered community (Millwood, VA)

Results - A human signature was found in Spout Run as it passed through upper and middle Millwood. No evidence of a human signature was found in Page Brook in an earlier report (Hagedorn et al., 1999), and no evidence of a human signature was found in any of the tributaries that form Spout Run in this study. There are 32 homes in upper Millwood, 21 homes in middle Millwood, and 13 homes in lower Millwood, all on individual septic systems. Repair or replacement of unsatisfactory systems (or installation of a community system) should result in removal of the human signature from Spout Run.

Sources:
Probable – Septic system (sewage infrastructure; human waste), Livestock (domestic animals; anthropogenic non-human sources), wildlife (non-anthropogenic)
Potential –
Possible –

2 - San Diego County Enterococcus Regrowth Study; Draft Final Report, June 11, 2011
John Griffith and D. Ferguson
Purpose - To investigate storm drains as a potential source of Enterococcus bacteria to San Diego's coastal waters during dry weather.

Results –The results of this study suggest that enterococci in these storm drain systems came from predominantly natural sources and include strains that are capable of growing on drain pipe surfaces. The results of the concrete coupon/growth study showed that enterococci were capable of attaching to and growing on concrete coupons. Testing of enterococci extracted from coupons in Cottonwood Creek revealed species and biotypes most closely related to freshwater plants and decomposed algae/vegetation. The majority (77%) of enterococci from the surfaces of coupons, pipe and cobble rock at a La Jolla storm drain were identified as an enterococcal species associated with plants.
A number of natural sources of enterococci were identified at Moonlight State Beach. In this study, up to 70% of creek water isolates were identified as a species commonly found on plants. Multivariate analysis of species and biotypes showed that enterococci in Cottonwood Creek were most similar enterococci found in decomposed algae and vegetation, freshwater plants and seawrack. At least 52% of enterococci in beach water were of a species found in plants, however 34% of isolates were either non-Enterococcus species or unidentifiable, suggesting the possibility of additional sources of enterococci that were not evaluated in this study. Some of the enterococci biotypes in beach water were the same ones found in decomposed algae and vegetation, freshwater plants and seawrack.
The low numbers of birds and predominance of E. faecalis in bird stools indicate that birds may not have been a major source of enterococci to creek and beach water, however the dissimilarity in enterococcal populations could also be related to different selection pressures.

All beach and storm drain/creek water samples tested for Bacteroidales indicated very low or non-detectable levels of the human marker, indicating that these samples had little or no evidence of human fecal material.

Sources:
Probable – MS4 Infrastructure (Human waste), avian (secondary wildlife), avian (non-anthropogenic)
Potential – Landscaping (irrigation and lawn clippings),
Possible – Wrackline, Plants (non-anthropogenic), seawrack, beach sand

121 - Escherichia coli and Enterococci at Beaches in the Grand Traverse Bay, Lake Michigan: Sources, Characteristics, and Environmental Pathways
Sheridan K. Haack, L.R. Fogarty, and C. Wright
http://www.glin.net/lists/beachnet/2007-07/pdf00000.pdf
Purpose - Overall objectives were to (i) quantify EC and ENT in dominant source materials and recreational waters; (ii) characterize selected source isolates using genomic (EC) or biochemical (ENT) profiling; (iii) identify associations between numbers of these two indicator bacteria groups and ambient conditions; (iv) identify processes that influence spatiotemporal variability of indicator bacteria at these beaches; and (v) evaluate standardized monitoring approaches in light of site-specific knowledge about sources and environmental processes

Results - Bird feces are likely one significant source of bacterial contamination to these beaches. Storm drains and the Boardman River contributed large numbers of EC and ENT to the bay, even during non-runoff conditions.
Sources:
Probable – Seawrack (vegetation and other detritus)
Potential –
Possible –

94 - Determining Sources of Fecal Pollution in a Rural Virginia Watershed with Antibiotic Resistance Patterns in Fecal Streptococci
C. Hagedorn, S.L. Robinson, J.R. Filtz, S.M. Grubbs, T.A. Angier, and R.B. Reneau Jr.
http://aem.asm.org/content/65/12/5522.full.pdf+html
Purpose - The objectives of this project were (i) to validate the method of using antibiotic resistance patterns in fecal streptococci and discriminant analysis (DA) to differentiate between human and animal sources and between certain types of animal sources with a larger database of known source isolates from a wider geographical region and (ii) to use this method in a watershed project to identify fecal pollution sources.

Results - The results presented affirm that antibiotic resistance patterns can be used with fecal streptococci to determine sources of fecal pollution in water. Results (detection of no human isolates) had a direct impact on water quality improvement in Page Brook, as local officials were able to focus restoration efforts on the actual sources (e.g., beef cattle) rather than on those that made no contribution to the water pollution.

Sources:
Probable – Cattle (domestic animals; anthropogenic non-human sources)
Potential – Waterfowl, deer unidentified (wildlife; non-anthropogenic)
Possible – Non-specific source (human waste)

69 - Influence of Freshwater Sediment Characteristics on Persistence of Fecal Indicator Bacteria
Laurence Haller, E. Amedegnato, J. Pote, and W. Wildi
http://www.springerlink.com/content/ju524662v67v4967/fulltext.pdf
Purpose - To investigate the effect of sediment characteristics such as particle grain size and nutrient and organic matter contents on the survival of fecal indicator bacteria including total coliforms, E. Coli, and Enterococcus.

Results - FIB survival in sediments and possible re-suspension are considerable significance for understanding permanent microbial pollution. Results revealed (1) FIB survived in sediments up to 50 days, (2) higher growth and lower decay rates of FIB in sediments with high levels of organic matter and nutrients and small grain size, (3) longer survival of Enterococcus compared to E. coli and total coliforms.

Sources:
Probable – Wastewater treatment plant (based on other studies), Soil/Sediment/Sand
Potential – Cattle and horses, storm runoff (MS4 Infrastructure; human waste), Agriculture
Possible – Septic (sewage infrastructure),Wastewater treatment plant, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use

193 - Soil: the environmental source of Escherichia coli and Enterococci in Hawaii's streams
C. M. Hardina, and R. Fukuda
http://md1.csa.com/partners/viewrecord.php?requester=gs&collection=ENV&recid=9200969&q=&uid=791338866&setcookie=yes
Purpose - To determine the concentrations and sources of Escherichia coli and enterococci in a typical stream (Manoa) in Hawaii.

Results - Soil is considered the most likely source for the high concentrations of indicator bacteria naturally present in the freshwater streams of Hawaii.

Sources:
Probable – Wastewater treatment plant (based on other studies), Soil/Sediment/Sand
Potential – Cattle and horses, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use
Possible – Septic (sewage infrastructure),Wastewater treatment plant, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use

61 - Combining targeted sampling and fluorometry to identify human fecal contamination in a freshwater creek
Peter G. Hartel, K. Rodgers, G.L. Moody, S.N.J. Hemmings, J.A. Fisher, and J.L. McDonald
http://www.iwaponline.com/jwh/006/0105/0060105.pdf
Purpose - The aim of this study was to conduct sampling at 2 reaches at Potato Creek, a freshwater creek in Georgia, and 1 tributary during baseflow and stormflow conditions and detect human sources of fecal contamination by using targeted sampling (finding hot spots of fecal contamination within the Creek and/or tributaries and re-sampling these spots) and fluorometry (detection of fluorescing compounds, optical brighteners, & laundry detergents)

Results - Humans, dogs, and cattle are the major suspected sources (not sampled) for fecal contamination in the Potato Creek reaches

Sources:
Probable -
Potential -
Possible – Broken home sewer line, dogs, cows, wildlife (non-anthropogenic),

63 - Drayton Harbor Watershed Microbial Source Tracking Pilot Study Phase 2: California Creek, Dakota Creek and Cain Creek Sub-watersheds
Hirsch Consulting Services
http://whatcomshellfish.whatcomcounty.org/Drayton/documents/DraytonHarborSanitarySurvey2010.pdf
Purpose - The objective of this study was to determine whether human or ruminant sources contribute to fecal contamination at selected sampling stations to inform follow-up investigations and corrective actions by Whatcom County and other agencies and to inform the Drayton Harbor Fecal Coliform TMDL Evaluation.

Results - Ruminant and human fecal sources threaten the shellfish harvest.

Sources:
Probable - Non-specific source (human waste), domestic animals,
Potential -
Possible -

67 - Sources and Mechanisms of Delivery of E. coli (bacteria) Pollution to the Lake Huron
Todd Howell
Purpose - To identify the potential sources of fecal pollution to the shoreline.

Results – The long-term fate of the potentially high E. coli loads delivered to the lake at these times is poorly understood. The association of E. coli with particulate material is thought to be a key mechanism by which survival and transport in the lake environment is enhanced.

Sources:
Probable – Agriculture,
Potential – Soil/Sediment/Sand
Possible - **Non-specific source (human waste), agriculture (listed under other with no degree of designation (probable, low, etc.)**

10 - Wrack promotes the persistence of fecal indicator bacteria in marine sands and seawater
Gregory J. Imamura, R.S. Thompson, A.B. Boehm, and J.A. Jay
http://onlinelibrary.wiley.com/doi/10.1111/j.1574-6941.2011.01082.x/full
Purpose - Study examined the relationship between beach wrack, FIB, and surrounding water and sediment at marine beaches along the California coast.

Results – FIB concentrations normalized to dry weight were the highest in stranded dry wrack, followed by stranded wet and suspended 'surf 'wrack. Laboratory microcosms were conducted to examine the effect of wrack on FIB persistence in seawater and sediment. Indigenous enterococci and Escherichia coli incubated in a seawater microcosm containing wrack showed increased persistence relative to those incubated in a microcosm without wrack. FIB concentrations in microcosms containing wrack-covered sand were significantly higher than those in uncovered sand after several days. These findings implicate beach wrack as an important FIB reservoir.

Sources:
Probable – Seawrack [1-Dry wrack (highest FIB), 2-wet wrack, 3-surf wrack]
Potential -
Possible -

57 - Presence and Growth of Naturalized Escherichia Coli in Temperate Soils from Lake Superior Watersheds
Satoshi Ishii, W.B. Ksoll, R.E. Hicks, and M.J. Sadowsky
http://aem.asm.org/content/72/1/612.full.pdf+html
Purpose - The goal of the study to was (i) examine the survival and persistence of E. coli populations in three soils in several coastal Lake Superior watersheds (extreme environmental conditions) and to determine if these E. coli strains have become naturalized to these soils, (ii) examine the genetic relatedness of soilborne E. coli strains from different locations, and (iii) determine if soilborne E. coli could actively multiply in the soils examined.

Results - E. Coli is able to survive and grow in soil, with growth occurring when temperature and nutrients are higher and able to survive in extreme environments (low temps). Animal feces of surrounding wildlife not shown to be likely source.
Sources:
Probable – Soil/Sediment/Sand
Potential -
Possible - Wildlife

156 - Sources and Persistence of Fecal Coliform Bacteria in a Rural Watershed
Rob C. Jamieson, R. J. Gordon, S. C. Tattrie, and G. W. Stratton
http://www.cawq.ca/journal/temp/journal/7.pdf#page=32
Purpose - Quantify the presence of fecal coliform bacteria in the surface waters of a rural watershed and to attempt to determine the primary sources of fecal pollution within rural watersheds.

Results - Fecal coliform levels frequently exceeded recreational water quality guidelines. At the watershed outlet, 94% of the collected samples exceeded the recreational water quality guideline during low flow conditions. Substantial bacterial loading was observed along stream reaches impacted by livestock operations. Bacterial loading was also observed along a stream reach that was not impacted by agricultural activities.

Sources:
Probable – Livestock
Potential -
Possible -

200 - The effect of cattle grazing on indicator bacteria in runoff from a Pacific Northwest watershed
M.D. Jawson, L.F. Elliott, K.E. Saxton, and D.H. Fortier
http://lshs.tamu.edu/docs/lshs/end-notes/the%20effect%20of%20cattle%20grazing%20on%20indica-1987218764/the%20effect%20of%20cattle%20grazing%20on%20indicator%20bacteria%20in%20runoff%20from%20a%20pacific%20northwest%20watershed.pdf
Purpose - Total coliform (TC), fecal coliform (FC), and fecal streptococcal (FS) numbers were monitored for 3 years to determine the effect of grazing on the presence of these organisms in runoff from a cattle grazed and a non-grazed watershed in the Pacific Northwest

Results - Sampling at several locations within the grazed watershed showed that sources of indicator bacteria were well distributed, and as a result were nonpoint after the initial runoff events. Thus, present FC recommendations developed for point-sources would not apply adequately to grazed land in the Pacific Northwest. Indicator bacteria as presently analyzed would not provide a basis for developing best management practices.

Sources:
Probable – Secondary Wildlife (Cows)
Potential -
Possible –

12 - 2009 Investigation of Spatial and Temporal Distribution of Human-specific Bacteroidales marker in Malibu Creek, Lagoon and Surfrider Beach

Jennifer Jay, R.F. Ambrose, V. Thulsiraj, and S. Estes
Purpose - The goal of the study is to understand the relationship between Fecal indicator bacteria (FIB) and human-specific Bacteroidales (HSB) in coastal wetland. The study examines the spatial & temporal relationship of human-specific Bacteroidales marker (HBM) & FIB in lower Malibu Creek, Lagoon, and Surfrider Beach during wet and dry weather to determine the presence of detectable concentrations of HBM in the lagoon and if concentrations of HBM correlate with FIB

Results - Of the 80 water samples analyzed within the Malibu watershed, five samples were positive for the human-specific HF183 Bacteroidales marker (HBM).The highest percent exceedance of FIB and HBM concentrations were measured during wet weather. During the study, 93.8% of the samples did not have detectable concentrations of HBM. These data do not rule out any particular potential sources of human fecal contamination.

Sources:
Probable -
Potential - storm drains
Possible - Septic systems, Tapia Wastewater Reclamation Facility disinfected discharge, wildlife and birds

98 - Microbial source tracking in a small southern California urban watershed indicates wild animals and growth as the source of fecal bacteria
Sunny C. Jiang, W. Chu B.H. Olson, J. He, S. Choi, J. Zhang, J.Y. Le, and P.B. Gedalanga
http://www.eng.uci.edu/files/07-1MST.pdf
Purpose - Apply three MST tools, namely, ARA, human viruses, and E. coli toxin biomarkers to aid in the cleanup of unknown pollution sources in Laguna Niguel. Laguna Niguel is a small urban watershed in southern California that experienced chronic fecal coliform and enterococci contamination, with concentrations on average of 2–4 orders of magnitude greater than State of California established type 2 recreational standards.

Results - Using three independent microbial source tracking methods, the results of this study indicate that human sewage was not a major contributor of fecal bacterial impairment in this small urban watershed. This study showed that rabbit feces contain one of the highest concentrations of Enterococcus spp. per unit weight.

Sources:
Probable – Urban land use (non-specific source), dogs (urban land use), cows and horses (rural open land use),
Potential –
Possible –

76 - Freshwater Beach Total Maximum Daily Load Microbial Source Tracking Study
Dr. Stephen H. Jones
http://des.state.nh.us/organization/divisions/water/wmb/tmdl/documents/sand_dam_appendix_b_beach.pdf
Purpose - The goal of this project was to investigate actual and potential bacterial sources at (3) public beaches. The approach reflects the latest concepts for efficient use of bacterial ribotyping for pollution source identification in New Hampshire, i.e., ribotyping of high priority samples and development of small local source species databases. This targeted approach was designed to optimize identification of the most significant contamination sources at the 3 beaches.

Results - Overall, birds were the most prevalent (37%) source species type, followed by livestock (24%), humans (5%), wild animals (4%) and pets (3%). The most commonly identified source species was geese (17 isolates), followed by cows and mixed avian (7) sheep (6), horses and ducks (3), septage, goat, wastewater effluent and dog (2), with single isolates identified as coming from deer, red foxes, wild turkeys and mixed wildlife.

Sources:
Probable – Livestock, birds (secondary wildlife)
Potential –
Possible – Non-specific source (human waste), pets, wildlife

99 - Tracking Bacterial Pollution Sources in Stormwater Pipes
Dr. Stephen H. Jones
http://www.unh.edu/users/unh/acad/colsa/marine-program/nhep/resources/pdf/trackingbacterialpollution-unh-03.pdf
Purpose - Determine the bacteria source species from two of the highest priority storm drain pipes that discharge to Hampton Harbor

Results - Many storm water/runoff studies have attributed fecal contamination to pet wastes. Of the four types of sources identified, pets were the least common, behind birds, humans and wildlife.

Sources:
Probable – Non-specific source (human waste), geese (secondary wildlife), cormorants (wildlife; non-anthropogenic)
Potential –
Possible – Cats and dogs (domestic animals; anthropogenic non-human sources), seagulls and pigeons (secondary wildlife), foxes, raccoons and coyotes (wildlife; non-anthropogenic)

32 - USING MULTIPLE ANTIBIOTIC RESISTANCE AND LAND USE CHARACTERISTICS TO DETERMINE SOURCES OF FECAL COLIFORM BACTERIAL POLLUTION
R. Heath Kelsey, G.I. Scott, D.E. Porter, B. Thompson, and L. Webster

http://www.springerlink.com/content/p5p4413ku0082707/fulltext.pdf
Purpose - Multiple Antibiotic Resistance (MAR) analysis and regression modeling techniques were used to identify surface water areas impacted by fecal pollution from human sources, and to determine the effects of land use on fecal pollution in Murrells Inlet, a small, urbanized, high-salinity estuary located between Myrtle Beach and Georgetown, South Carolina.

Results - MAR results suggest that the majority of the fecal pollution detected in the Murrells Inlet estuary may be from non-human sources, including fecal coliforms isolated from areas in close proximity to high densities of active septic tanks.

Sources:
Probable -
Potential -
Possible -

144 - Bacteria Attenuation Modeling and Source Identification in Kranji Catchment and Reservoir
Kathleen B. Kerigan, and J.M. Yeager
http://censam.mit.edu/publications/yeager.pdf
Purpose - Determine the bacterial loading of Kranji Catchment and Reservoir and how this will affect planned recreational use of the reservoir.

Results - Farm run-off near the reservoir was the bacterial source of greatest concern. The relatively high concentrations coupled with the short travel time, which diminishes opportunity for attenuation, resulted in high concentrations reaching the reservoir downstream levels.

73 - Draft Calleguas Creek Watershed Quantitative Microbial Source Tracking Study
Beverly Kildare, V. Rajal, S. Tiwari, D. Thompson, B. McSwain, S. Wuertz, D. Bambic, and G. Reide (Report Prepared by UC Davis in Collaboration with Larry Walker Associates)
Wuertz, S., Bambic, D., and Reide, G. (Report Prepared by UC Davis in Collaboration with Larry Walker Associates)
http://www.calleguas.com/ccwmp/DRAFT_CCW_MST_061406.pdf
Purpose - The goal of this microbial source tracking (MST) study was to provide quantitative, host-specific fecal source data and assist in the development of a bacteria TMDL for the Calleguas Creek Watershed(CCW).

Results - Urban areas were found to be sources of human and canine bacteria to Arroyo Simi and Conejo Creek. The Tapo Canyon site, which is upstream of urban influences, exhibited the lowest concentrations and ratios of the mixed-human marker, but the highest concentrations and ratios of the cow/horse marker. Analysis of tertiary-treated wastewater samples indicates that mixed-human Bacteroidales concentrations may be relatively high in discharged effluent. However, such cells are most likely non-viable and thus not associated with water quality objective exceedances.

Sources:
Probable – Non-specific source (human waste), dogs (canine urban land use), cows and horses (rural and open space)
Potential –
Possible –

100 - Non-point source pollution: Determination of replication versus persistence of Escherichia coli in surface water and sediments with correlation of levels to readily measurable environmental parameters
Julie Kinzelman, S.L. McLellan, A.D. Daniels, S. Cashin, A. Singh, S. Gradus, and R. Bagley
http://www.iwaponline.com/jwh/002/0103/0020103.pdf
Purpose - Racine, Wisconsin, located on Lake Michigan, experiences frequent recreational water quality advisories in the absence of any identifiable point source of pollution. This research examines the environmental distribution of Escherichia coli in conjunction with the assessment of additional parameters (rainfall, turbidity, wave height, wind direction, wind speed and algal presence) in order to determine the most probable factors that influence E. coli levels in surface waters.

Results - This study indicates that persistence, rather than environmental replication of E. coli, is responsible for the majority of microorganisms recovered from foreshore sands, submerged sands and surface waters at Racine, Wisconsin, beaches along Lake Michigan.

Sources:
Probable – Non-specific source (persistence in surface water; non-anthropogenic), Soil/Sediment/Sand (persistence)
Potential –
Possible –

135 - Source tracking faecal contamination in an urbanised and a rural waterway in the Nelson-Tasman region, New Zealand
M. Kirs, V.J. Harwood, A.E. Fidler, P.A. Gillespie, W.R. Fyfe, A.D. Blackwood, and C.D. Cornelisen
http://www.tandfonline.com/doi/pdf/10.1080/00288330.2010.535494
Purpose - Eight MST markers, including general, ruminant and human-associated Bacteroidales markers, a duck-associated E2 marker, a gull-associated Catellicoccus marimammalium marker and three additional human markers [Enterococcus faecium esp gene, Methanobrevibacter smithii nifH gene, and human polyoma viruses (HPyVs)] were tested for host specificity and sensitivity using an array of animal faecal samples of known origin and wastewater samples.

Results - The validation and application of a suite of end-point PCR assays for MST markers enabled us to identify the presence of faecal contamination from multiple sources, including humans, in a New Zealand urbanised waterway. Outcomes demonstrate that MST markers developed overseas can be utilised in New Zealand context.

150 - PISMO BEACH FECAL CONTAMINATION SOURCE IDENTIFICATION STUDY

Christopher L. Kitts, M.W. Black, M.Y. Moline, A.K. Hamrick, I.C. Robbins, A.A. Schaffner, and N.I. Boutet

http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1325&context=bio_fac

Purpose - Identify the biological sources of fecal contamination as well as the physical and environmental factors that influence the levels of bacteria in the ocean waters at Pismo Beach, California.

Results - The main source of fecal contamination on the beach is bird droppings near the pier. Both wave direction and current direction worked to push high concentrations of FIB away from the pier as the main source of fecal contamination.

Sources:
Probable – Sewage Infrastructure, Domestic animals (dogs, cats and horses), Secondary wildlife (cows, pigeons and gulls)
Potential –
Possible –

101 - Presence and Sources of Fecal Coliform Bacteria in Epilithic Periphyton Communities of Lake Superior

Winfried B. Ksoll, S. Ishii, M.J. Sadowsky, and R.E. Hicks

http://aem.asm.org/content/73/12/3771.full.pdf+html

Purpose - (i) determine if fecal coliforms and E. coli populations are present and persist in periphyton communities from a harbor and Lake Superior, (ii) identify the most probable sources of E. coli found in periphyton, (iii) use laboratory microcosms to examine colonization and survival of E. coli in natural periphyton communities, and (iv) estimate the contribution of periphyton borne E. coli to overlying waters.

Results - Although many E. coli strains isolated from periphyton may have originated from waterfowl and sewage effluent, other strains appeared to be unique to the periphyton studied and may have developed self-sustaining naturalized populations in these communities. E. coli cells attached to periphyton, whether they are unique to these periphyton communities or not, can detach and contribute to fecal coliform numbers measured in coastal waters. This confounds the use of fecal coliforms as a reliable indicator of recent fecal contamination of recreational waters.

Sources:
Probable –
Potential – Sewage effluent (wastewater treatment plant; human waste), waterfowl (wildlife; non-anthropogenic), algae (non-anthropogenic)
Possible –

65 - Microbial Source Tracking Study for South Cypress Creek
Thomas B. Lawrence, P.E. (City of Memphis, Division of Public Works)
Purpose - The objective of this project was to be able to determine possible sources of fecal coliform levels found in South Cypress Creek, as well as to be able to try to quantify the impacts. By identifying the sources of the impacts, the City will work to achieve the goal of the Clean Water Act by addressing the specific sources where possible.

Results – Data indicated that there may be both diffuse sources of Avian fecal coliform (such as deposited areas that are washed into the creek at a slow rate), as well as direct discharges into the creek, providing the high numbers. The total human impact was fairly low. Thus, pet contributions may be more related to storm water runoff, rather than would be seen with the other major source types which may be related to direct contact with the creek water. For sources attributed to Wild Animals, the number of isolates was higher than all of the other sources in all fecal result groups, except for the "TNTC" group, where it was second to Avian.

Sources:
Probable – avian (secondary wildlife), wildlife (including birds),
Potential -
Possible - Non-specific source (human waste), domestic animals,

39 - LINKING ON-FARM DAIRY MANAGEMENT PRACTICES TOSTORM-FLOWFECAL COLIFORM LOADING FOR CALIFORNIA COASTALWATERSHEDS
David J. Lewis, E.R. Atwill, M.S. Lennox, L. Hou, B. Karle, and K.W. Tate
http://waterquality.ucanr.org/documents/Dairy_Management_Resources7451.pdf
Purpose - We have conducted a systems approach study of 10 coastal dairies and ranches to document fecal coliform concentration and loading to surface waters at the management decision unit scale. Water quality samples were collected on a storm event basis from loading units that included: manure management systems; gutters; storm drains; pastures; and corrals and lots.

Results – Fecal coliform load from units of concentrated animals and manure are significantly more than units such as pastures while storm flow amounts were significantly less. Fecal coliform concentrations demonstrate high variability both within and between loading units. Fecal coliform concentrations for pastures range from 206 to 2,288,888 cfu/100 ml and for lots from 1,933 to 166,105,000 cfu/100 ml.

Sources:
Probable - Manure Management Systems, Stockpiles, and lots (agriculture),
Potential – MS4 Infrastructure (human waste), pasture (land use)
Possible -

15 - Evaluation of Chemical, Molecular, and Traditional Markers of Fecal Contamination in an Effluent Dominated Urban Stream
R.M. Litton, J.H. Ahn, B. Sercu, P.A. Holden, D.L. Sedlak, and S.B. Grant
http://pubs.acs.org/doi/abs/10.1021/es101092g

Purpose - To perform a quantitative sanitary survey of the Middle Santa Ana River, in southern California, utilizing a variety of source tracking tools, including traditional culture-dependent fecal markers, speciation of enterococci isolates, culture-independent fecal markers, and chemical markers of sewage and wastewater

Results - The results support the notion that regrowth of fecal indicator bacteria (FIB) in river sediments may lead to a decoupling between FIB and pathogen concentrations in the water column and thus limit the utility of FIB as an indicator of recreational waterborne illness in inland waters.

Sources:
Probable - in-situ growth in streambed sediments
Potential - effluent stream tributary to Santa Ana River, tributary to RW (Riverside WWTP plant stream tributary to Santa Ana River
Possible - Riverside WWTP & discharge pipe

128 - Snapshot investigation of likely contaminant sources in the Tilligerry Estuary catchment (Zones 5A and 5B)
S.A. Lucas, P.M. Geary, P.J. Coombes, and R.H. Dunstan
http://scholar.googleusercontent.com/scholar?q=cache:F75WyRF5YdUJ:scholar.google.com/&hl=en&num=100&as_sdt=0,5&as_vis=1
Purpose - a) To provide a "snapshot" of water quality in major surface waters draining to the estuary and within the estuary after a particularly wet period. The samples were analysed for nutrients (orthophosphate and nitrate), total coliforms, faecal coliforms, E.Coli, faecal streptococci and faecal sterols and; b) To interpret the most likely sources of faecal contamination from the data obtained as elevated faecal coliform concentrations had been recorded after significant rainfall in the past.

Results - However, the high microbial concentrations observed in major surface drains on the western and eastern side of the estuary also warrant further investigation, however it is clear that the majority of faecal contamination in the estuary is from agricultural land uses. A management program to control and mitigate runoff sources from agricultural lands in the catchment is therefore seen as an integral part of any plan to reduce faecal contamination in Tilligerry estuary.

Sources:
Probable –Human Waste (Non-specific source), Herbivores (Secondary Wildlife)
Potential -
Possible -

62 - Bacteriological methods for distinguishing between human and animal faecal pollution of water: results of fieldwork in Nigeria and Zimbabwe
D. Duncan Mara and J. Oragui
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2536379/pdf/bullwho00087-0144.pdf

Purpose - Recently, methods have been developed to distinguish between human and animal faecal pollution in temperate climates. The present study assessed the applicability and practicality of these methods in tropical countries.

Results - Ruminant and human fecal sources threaten the shellfish harvest.

Sources:
Probable –domestic animals,
Potential - Non-specific source (human waste), Non-specific source (anthropogenic non-human source),
Possible -

207 - Identifying sources of fecal contamination inexpensively with targeted sampling and bacterial source tracking
J.L. McDonald, P.G. Hartel, L.C. Gentit, C.N. Belcher, K.W. Gates, K. Rodgers, J.A. Fisher, K.A. Smith, and K.A. Payne
http://www.water.rutgers.edu/Source_Tracking/Enterococcus/IdentifyingSourcesofFecalContaminationInexpensivelywithTargetedSamplingandBacterialSource.pdf
Purpose - Our objective was to identify the sources of fecal contamination inexpensively at St. Andrews Park and Sea Island during calm and stormy weather conditions using targeted sampling and two or more BST methods: Enterococcus speciation, the detection of the esp gene, and fluorometry.

Results - Targeted sampling, when combined with two or more of three BST methods-enterococcal speciation, detection of the esp gene, and fluorometry--was able to identify sources of fecal contamination quickly, easily, and inexpensively.

Sources:
Probable – Wildlife (Birds)
Potential -
Possible –Human Waste (Non-specific source), Sewage infrastructure (leaking sewer lines), Unspecified wildlife

26 - Application of Bacteroides fragilis Phage as an Alternative Indicator of Sewage Pollution in Tampa Bay, Florida
Molly R. McLaughlin, and J.B. Rose
http://www.springerlink.com/content/922l116k3286u5p3/fulltext.pdf
Purpose - The use of bacteriophages were evaluated in the drainage basins of Tampa Bay

Results – In this study, the phages that infect B. fragilis host RYC2056 (RYC), including phage B56-3, and host ATCC 51477-HSP40 (HSP), including the human specific phage B40-8, were evaluated in the drainage basins of Tampa Bay, 7 samples (n=62), or 11%,
tested positive for the presence of phages infecting the host HSP, whereas 28 samples, or 45%, tested positive using the host RYC.

Sources:
Probable – Septic (sewage infrastructure),
Potential -
Possible -

4 - PB Point Bacterial Source Investigation Final Data Report
MEC- Weston and City of San Diego
Purpose - The goal of this study was to use molecular and standard bacterial indicator techniques to assess the host origin of the bacteria found in the receiving waters at PB point.

Results - The results of the PCR analysis are also presented in Table 2. Of the ten receiving water samples collected (not including duplicates), four (75-R on 8/15, 75R on 8/18, 75-L on 8/18 and 75-R on 8/20) were positive for the general PCR marker (GB), suggesting the presence of fecal material. Among the four samples that tested positive for the general marker, two were positive for at least one of the human-specific markers (75-L on 8/18 and 75-R on 8/20), which suggests the presence of bacteria from human origin.

Although the values for the bacterial indicators from all of the storm drain samples were high, only one (not including duplicates) of the five storm drain samples was positive for the general PCR marker (SD-0 on 8/15). None of the storm drain samples were positive for either of the two human markers.

Sources:
Probable –
Potential – Non-specific source (human waste)
Possible -

55 - MISSION BAY - Clean Beaches Initiative Bacterial Source Identification Study
MEC- Weston and City of San Diego
Purpose - The overall goal of this study was to identify the sources of bacterial contamination to Mission Bay.

Results -Results from both MST methods utilized in Phase II confirmed that the large majority of the enteric bacteria in Mission Bay originates from birds and contributions from human sources are insignificant

Sources:
Probable – Avian (secondary wildlife),
Potential –Dogs, over-irrigation, MS4 Infrastructure (delta sediment at storm drain outlet)
Possible - park restrooms and RV pump stations (human waste), boats and homeless(mobile sources), groundwater (non-anthropogenic), marine mammals, bay sediment

105 - Temporal and Spatial Variability of Fecal Indicator Bacteria: Implications for the Application of MST Methodologies to Differentiate Sources of Fecal Contamination
Marirosa Molina
http://www.environmental-center.com/Files%5C7698%5Carticles%5C5788%5CMolina20600.pdf
Purpose - Identify and compare the temporal and spatial variability of fecal indicator bacteria from a specific host in manure and water samples and evaluate the implications of such variability on microbial source tracking approaches and applications.

Results - Building an enterococci library is a time-consuming, expensive approach that has the potential to provide a great deal of information when the proper statistical analytical approach (in this case it was cluster analysis) is used to interpret the results. Application of a library-independent approach, such as the Bacteroides markers allows for a much faster and possibly less expensive results, but there remains a lack of thorough temporal, spatial and specificity analyses of the few genetic markers available so far.

Sources:
Probable – Cattle (domestic animals; anthropogenic non-human sources)
Potential –
Possible –

38 - Bacteria Monitoring and Source Tracking in Corpus Christi Bay at Cole and Ropes Parks
Joanna Mott, M. Lindsey, R. Sealy, and A. Smith
http://www.cbbep.org/publications/virtuallibrary/1010.pdf
Purpose - In this study water samples from the six Texas Beach Watch stations at Ropes and Cole Parks were analyzed to detect the esp marker as an indicator of human contamination at these locations. Additionally, data on three other human-specific markers--Bacteroidales, Human 2 Polyoma Viruses (HPyVs), and ethanobrevibacter.smithii—from another study, are included in this report for comparison with the esp analysis results.

Results - Human source contamination was detected at Ropes and Cole Park stations under ambient weather conditions as measured by several human-specific markers. The esp gene was detected when levels of enterococci at Ropes Park were higher following rainfall and suggest a human contribution at this location presumably either from storm drain outflow or non-point source run-off. For Ropes and Cole Parks, a broader bacteria source tracking project is recommended to examine not only human, but other sources of contamination.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible – MS4 Infrastructure (human waste),

72 - Bacteria Source Tracking on the Mission and Aransas Rivers
Joanna Mott, R. Lehman, Ph.D. and A. Smith
Purpose - In this study, bacteria source tracking (BST) was used to evaluate the sources of fecal contamination in the Mission and Aransas River segments and to provide additional data for assessment of sources of contamination into Copano Bay, the water body into which both segments empty.

Results - The majority of unknown source isolates collected from water samples at the five sampling stations along the Mission and Aransas tidal segments were classified as human source. Overall, 63.7-66.9% of unknown source isolate profiles from the composite (ARA+CSU) dataset were classified as treated human sources (originating from treated wastewater effluent). The remaining unknown source isolates were classified as livestock animals and wildlife, with cow, horse and duck contributions accounting for the majority of the animal sources in both the composite dataset and PFGE profiles.

Sources:
Probable – Wastewater treatment plant, cows, horses, ducks
Potential –
Possible – Gulls (secondary wildlife), hogs

41 - Multi-scale landscape factors influencing stream water quality in the state of Oregon
Maliha S. Nash, D.T. Heggem, D. Ebert, T.G. Wade, and R.K. Hall
http://www.springerlink.com/content/y17u3uh60155w313/fulltext.pdf
Purpose - This study used the State of Oregon surface water data to determine the likelihood of animal pathogen presence using enterococci and analyzed the spatial distribution and relationship of biotic (enterococci) and biotic (nitrogen and phosphorous) surface water constituents to landscape metrics and others (e.g. human use, percent riparian cover, natural covers, grazing, etc.).

Results – Landscape metrics related to amount of agriculture, wetlands and urban all contributed to increasing nutrients in surface water but at different scales. The probability of having sites with concentrations of enterococci above the threshold was much lower in areas of natural land cover and much higher in areas with higher urban land use within 60 m of stream. A 1% increase in natural land cover was associated with a 12% decrease in the predicted odds of having a site exceeding the threshold. Opposite to natural land cover, a one unit change in each of manmade barren and urban land use led to an increase of the likelihood of exceeding the threshold by 73%, and 11%, respectively. Change in urban land use had a higher influence on the likelihood of a site exceeding the threshold than that of natural land cover.

Sources:
Probable - Urbanized land use
Potential -
Possible – Agriculture

66 - Coastal Nonpoint Source Pollution Monitoring Program
New Jersey Department of Environmental Protection
Purpose - To identify the causes of the degrading water quality in the upper Navesink River. Perform stormwater monitoring to delineate major sources of fecal contamination. Utilize specialize tests, including coliphage and Multiple Antibiotic Resistance (MAR) analyses, to identify the sources of contamination (i.e., human, domestic animal, and wildlife). Once identified, actions can be recommended and taken to eliminate or reduce the impact.

Results – Results for Microbial Source Tracking indicators (F+RNA coliphage and Multiple Antibiotic Resistance) suggest a human source of fecal contamination at sites. Sites were identified as 'hot spots' for further source investigations.

Sources:
Probable - Non-specific source (human waste),wildlife
Potential – Domestic animals,
Possible -

1 - Multi-tiered Approach Using Quantitative Polymerase Chain Reaction for Tracking Source of Fecal Pollution to Santa Monica Bay, Ca, February 2005
Rachel T. Noble, J.F. Griffith, A.D. Blackwood, J.A. Fuhrman, J.B. Gregory, X. Hernandez, X. Liang, A.A. Bera, and K. Schiff
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2005_06AnnualReport/AR0506_181-194.pdf
Purpose - The objective of this study was to identify the contribution and quantify the loading of fecal contamination to the SMB using a multi-tiered approach. No discussion on what fecal source types (agriculture, birds, dogs) are impacting Santa Monica Bay

Results - Measurements of Bacteroides sp. and enterovirus indicated the presence of human fecal contamination throughout the system. Bacteroides sp. was present in 33% of mainstem samples. Enterovirus was present in 44% of mainstem samples. The concordance among these measurements was nearly complete; almost every location that detected Bacteroides sp. was also positive for enterovirus.

Sources:
Probable - Non-specific Source (human waste)
Potential -
Possible-

108 - Use of Fecal Steroids to Infer the Sources of Fecal Indicator Bacteria in the Lower Santa Ana River Watershed, California: Sewage Is Unlikely a Significant Source
James A. Noblet, D.L. Young, E.Y. Zeng and S. Ensari
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/444_fecal_steroids.pdf
Purpose - Utilize a suite of fecal steroids, as chemical markers to examine whether sewage was a significant source of FIB within the lower Santa Ana River watershed.

Results - The results implied that sewage was not a significant source of fecal steroids, and therefore perhaps FIB to the study area. Instead, birds may be one possible source of the intermittently high levels of FIB observed in the lower Santa Ana River watershed and the nearby surf zone.

Sources:
Probable –
Potential – Gulls (secondary wildlife; anthropogenic non-human sources)
Possible – Sewage infrastructure (human waste), dogs (domestic animals; anthropogenic non-human sources)

109 - Fecal source tracking by antibiotic resistance analysis on a watershed exhibiting low resistance
Yolanda Olivas, and B.R. Faulkner
http://www.springerlink.com/content/k02q5v6748702773/fulltext.pdf
Purpose - To test the efficiency of the antibiotic resistance analysis (ARA) method under low resistance by tracking the fecal sources at Turkey Creek, Oklahoma exhibiting this condition.

Results - The original seasonal and annual DA of the stream sources showed no significant difference between human and livestock input rates in winter, spring and summer ($0.56 \le P \le 0.76$). Deer was consistently lower than the other two sources ($0.00 \le P \le 0.30$). In fall, the human source predominated over livestock and deer ($P<0.0001$). Revision of the original DA using the rates of misclassification, decreased classification into the human and deer sources by 6–7% ($0.22 \le P \le 0.33$), and increased classification into livestock by 13–14% ($0.04 \le P \le 0.06$), showing the significance of the original DA misclassification. In conclusion, the major effect of low antibiotic resistance to this ARA work was a significant level of negative misclassification into the livestock source.

Sources:
Probable – Non-specific source (human waste), livestock (domestic animals; anthropogenic non-human sources)
Potential – Deer (wildlife; non-anthropogenic)
Possible –

143 - Investigation of Faecal Pollution and Occurrence of Antibiotic Resistant Bacteria in the Mooi River System as a Function of a Changed Environment
M.J. Pantshwa, A.M. van der Walt, S.S. Cilliers, and C.C. Bezuidenhout
http://www.ewisa.co.za/literature/files/2008_137.pdf
Purpose - Water quality monitoring and assessments are of paramount importance to identify the river confluence vulnerable to the pollution impacts of urbanization. Investigate some physico-chemical parameters, levels of faecal pollution and occurrence of antibiotic resistant bacteria in the Mooi River system as a function of a changed environment.

Results - Non-human sources contributed greater towards faecal pollution. Urban gradient was recognized in terms of faecal indicator species distribution. Higher levels of antibiotic resistant bacteria were detected in urban sites when compared to lower upstream and elevated downstream levels.

75 - Middle Rio Grande Microbial Source Tracking Assessment Report

Parsons Water & Infrastructure Inc.

Purpose - The objective of this project was to identify specific sources of fecal coliform causing high levels of bacteria in the Middle Rio Grande.

Results - Overall, ribotyping results show, the largest fraction of E. coli matched those found in avian sources, followed by canine, human/sewage, rodents, bovine, and equine. The source of approximately 9 percent of the E. coli could not be identified. With the exception of rodents, only a few species of wild mammals were identified as sources of fecal coliform found in water: deer or elk, raccoon, coyote, bear, and opossum. It should be noted that an unknown fraction of the canine isolates may be from coyotes and foxes, as many E. coli strains are resident both in domestic dogs and wild canines.

Sources:
Probable – Cats, dogs, birds (wildlife)
Potential – Non-specific source (human waste), livestock, rodents (secondary wildlife), Wildlife (deer or elk, raccoon, coyote, bear, and opossum)
Possible –

125 - Bacterial Contamination and Antibiotic Resistance in Fecal Coliforms from Glacial Water Runoff

S.P. Pathak, and K. Gopal

http://www.springerlink.com/content/fup31h3742514123/fulltext.pdf

Purpose - Assess the bacteriological contamination in glacial water runoff from the Gangotri glacier and Gangetic river system (Gaumukh to Rishikesh) by enumerating aerobic heterotrophs, coliforms, fecal coliforms and fecal streptococci. Antibiotic resistance among the fecal coliforms, identified as E. coli, was also studied.

Results - Contamination of coliform was observed in all samples, while fecal coliform and fecal streptococci were detected in 17 and 18 samples, respectively (Fig. 2). Thus, bacteriological analysis exhibited maximum contamination in most of the water samples from post-Gangotri and Gangetic stations. The observed increase in the proportion of coliforms and fecal coliforms was statistically significant ($p < 0.001$). The counts of fecal streptococci in all study stretches were too low for statistical comparison.

129 - Fecal BMAP Implementation: Identification of Probable Sources in the Butcher Pen Creek Watershed
PBS&J
http://publicfiles.dep.state.fl.us/dear/BMAP/LowerStJohns/Tributaries%20Fecal%20Coliform%20BMAPs/Technical_Reports/ButcherPen/Final%20Draft%20Butcher%20Pen%20WBID%202322%20Tech%20Report%20041008.pdf
Purpose - FDEP has verified 54 tributaries of the Lower St. Johns River—located throughout Duval County and in small portions of Clay and St. Johns Counties—as impaired for fecal coliform, and TMDLs must be developed for these waterbodies. Local stakeholders in the Lower St. Johns Basin, in conjunction with FDEP, are currently working to develop a Basin Management Action Plan (BMAP) to implement the TMDLs for fecal coliform.

Results - Elevated levels of fecal coliforms following rainfall may be an indication that unidentified pollution sources (e.g., leaking wastewater conveyance systems) are being transported by stormwater into Butcher Pen Creek. This evaluation indicates that the probable sources of fecal contamination in the Butcher Pen Creek WBID are human-related. Although Butcher Pen Creek does not have a designated septic tank phase-out area, some areas of the basin have likely had OSTDS failures, as indicated by the existence of septic tank repair permit applications, especially in the northeast corners of the watershed. Therefore, it is likely that there still remain isolated and problematic septic systems that are contaminating the neighboring surface waters.

Sources:
Probable – Sewage infrastructure (SSO events),
Potential – Wastewater discharge
Possible –

34 - Origin and spatial–temporal distribution of faecal bacteria in a bay of Lake Geneva, Switzerland
John Poté, N. Goldscheider, L. Haller, J. Zopfi, F. Khajehnouri, and W. Wildi
http://doc.rero.ch/lm.php?url=1000,43,4,20100511154847-XI/Pot_John_-_Origin_and_spatial-temporal_distribution_of_faecal_bacteria_20100511.pdf
Purpose - To quantify the input flux rates of faecal bacteria from the main contamination sources and to assess their spatial and temporal distribution in the bay, in order to estimate the human health risk related to recreational activities and drinking water use.

Results - The highest FIB concentrations in the near-surface water of the bay consequently occur during floods and mixed lake conditions. Although the thermocline protects the epilimnion from contamination in summer, effluent water may spread in the hypolimnion and reach the drinking-water pumping station 3.8 km further to the west.

Sources:
Probable – Wastewater Treatment Plant
Potential –
Possible –

110 - Classification Tree Method for Bacterial Source Tracking with Antibiotic Resistance Analysis Data

Bertram Price, E.A. Venso, M.F. Frana, J. Greenberg, A. Ware, and L. Currey

http://aem.asm.org/content/72/5/3468.full.pdf+html

Purpose - Apply the statistical method known as classification trees to build a model for BST for the Anacostia Watershed in Maryland.

Results - Applying the tree classification model to the 1,565 Anacostia River water isolates yielded the following distribution of sources: 468 (29.9%) pet, 222 (14.2%) human, 437 (27.9%) livestock, and 438 (28.0%) wildlife. These results were determined from analysis of all the water isolates, which represent six monitoring stations with samples collected monthly for 1 year. Therefore, the source distribution presented here does not account for the distribution of high-flow and low-flow periods, which may contribute different sources to the streams. Also, note that bacterial sources can be site specific in a watershed, given the non-conservative nature of bacterial transport. For the purpose of this analysis, all the water isolates from the six monitoring stations were used to estimate the overall watershed relative source contributions. The results based on this averaging method indicate that humans contribute the least bacterial contamination to the Anacostia River. The other sources of bacterial contamination are evenly distributed among pet animals, livestock, and wildlife.

Sources:
Probable – Pets and livestock (domestic animals; anthropogenic non-human sources), wildlife (non-anthropogenic)
Potential – Non-specific sources (human waste)
Possible –

113 - Quantitative microbial faecal source tracking with sampling guided by hydrological catchment dynamics

G. H. Reischer, J.M. Haider, R. Sommer, H. Stadler, K.M. Keiblinger, R. Hornek, W. Zerobin, R.L. Mach, and A.H. Farnleitner

http://onlinelibrary.wiley.com/doi/10.1111/j.1462-2920.2008.01682.x/pdf

Purpose - Apply modern quantitative microbial source tracking methods on a large and complex karstic spring catchment in context with hydrology and other water quality parameters over a prolonged period of time in order to comprehensively, qualitatively and quantitatively characterize the pollution sources.

Results - 1) Established and evaluated a new sampling concept with consideration for the whole seasonal hydrological catchment variability and special emphasis on strong pollution events.
2) Demonstrated the ability of quantitative microbial source tracking studies to quantitatively link source-specific marker levels to general faecal pollution indicators in order to estimate the contribution of one source group to total faecal pollution as measured in conventional faecal monitoring.

3) Showed that the thorough investigation of catchment hydrology and pollution dynamics is a prerequisite for successful quantitative microbial source tracking study design.

Sources:
Probable – Ruminant (wildlife; non-anthropogenic)
Potential – Non-specific sources (human waste)
Possible – Soil/Sediment/Sand

133 - Assessment of Sources of Bacterial Contamination At Santa Cruz County Beaches
John Ricker and S. Peters
ftp://ftpdpla.water.ca.gov/users/prop50/10045_SantaCruz/Work%20Plan%20CD%2004/reference%20plans%20and%20background%20information/Sources%20of%20Contamination%20at%20SCC%20Beaches%202005.pdf
Purpose - Determine the source and health threat of elevated bacteria levels at Santa Cruz County beaches

Results - The most significant source of beach contamination in Santa Cruz County is discharge from the creeks, with a high urban runoff component during both wet and dry weather. 22 point plan to be implemented to improve water quality

Sources:
Probable – Non-specific sources (human waste), Sewage infrastructure (storm drains), Domestic animals (dogs), Secondary wildlife (birds), Wildlife (rats)
Potential –
Possible –

42 - Bacterial Source Tracking Pilot Study DNA Fingerprinting, Human Bacteroidetes ID and Human Enterococci ID
Rogue Valley Council of Governments
Natural Resources Department
Purpose - The purpose of the pilot study was 1) to determine whether bacteria found in local streams is from human or animal sources and 2) to evaluate different BST methodology for future use within the Rogue Valley.

Results - DNA Fingerprinting results show that animal fecal matter is present, but were inconclusive in identifying whether human contamination was present. Many of the analyzed colonies could not be matched to animal or human sources. However, based on the isolates identified, animals are the primary contributor of bacteria to Ashland Creek, Baby Bear, and Griffin Creek (31 of 50).

Sources:
Probable - Domestic animals, wildlife,
Potential -
Possible – Non-specific source (human waste)

7 - Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather

Kenneth Schiff, J. Griffith, and G. Lyon

http://www.sccwrp.org:8060/pub/download/DOCUMENTS/TechnicalReports/448_reference_beach.pdf

Purpose - The contribution of non-human sources of bacteria was quantified at coastal reference beaches in southern California. Provides an overview of sampling methods and analytical results for reference beaches are discussed. Bacteria sources were not identified

Results – Based on the results from this study, natural contributions of nonhuman fecal indicator bacteria were sufficient to generate exceedances of the State of California water quality thresholds during wet weather. Total coliform, E. coli, and enterococcus samples collected during wet weather exceeded water quality thresholds greater than 10 times more frequently during wet weather than during recent dry weather in summer or winter, although the frequency differed by beach. San Onofre State Beach had the greatest concentrations of bacteria and the greatest frequency of water quality threshold exceedances. This may have been the result of several factors that we cannot disentangle. First, San Onofre Creek was the largest watershed we sampled, which may have led to a greater number of nonhuman sources of fecal indicator bacteria upstream. Second, San Onofre Creek had the largest and most mature lagoon of any site sampled, which was located at the beach interface and may have attracted nonhuman fecal sources(i.e. birds). Third, San Onofre Creek was the only discharge where we found human enteric virus. The San Onofre Creek watershed had the greatest fraction of developed land use (3%) of any of the other watershed systems and human activities are known to occur in the lower part of this watershed.

Sources:

Probable – Non-specific source (anthropogenic)

Potential – Non-specific source (human waste)

Possible –

221 - Presence of Bacteroidales as a Predictor of Pathogens in Surface Waters of the Central California Coast

A. Schriewer, W.A. Miller, B.A. Byrne, M.A. Miller, S. Oates, P.A. Conrad,, D. Hardin, H.H. Yang, N. Chouicha, A. Melli, D. Jessup, C. Dominik, and S. Wuertz

http://ukpmc.ac.uk/articles/PMC2935056

Purpose - Evaluate the value of Bacteroidales genetic markers and fecal indicator bacteria (FIB) to predict the occurrence of waterborne pathogens in ambient waters along the central California coast.

Results - The ability to predict pathogen occurrence in relation to indicator threshold cutoff levels was evaluated using a weighted measure that showed the universal Bacteroidales genetic marker to have a comparable or higher mean predictive potential than standard FIB. This predictive ability, in addition to the Bacteroidales assays providing information on contributing host fecal sources, supports using Bacteroidales assays in water quality monitoring programs.

77 - Tracking Sources of Fecal Pollution in a South Carolina Watershed by Ribotyping Escherichia coli: A Case Study

Troy M. Scott, J. Caren, G.R. Nelson, T.M. Jenkins, and J. Lukasik

http://sourcemolecular.com/pdfs/scott3.pdf

Purpose - To describe the effective use of the ribotyping microbial source tracking procedure to determine the source(s) of Escherichia coli within a South Carolina watershed.

Results - Prior to investigating potential fecal inputs into this watershed, a significant human source was suspected as the primary input; however, of the 515 E. coli isolated from water samples collected during the course of this study, 88% were typed as being of animal fecal origin. Thus, this study was integral in the realization that animals may be a significant source of contamination and that remediation efforts should be redirected to accommodate these findings. Of the 454 animal isolates analyzed, 51 RT profiles were directly matched from a specific animal source. Of these, 22 (43%) were classified as coming from deer feces and 9 (18%) directly matched those generated from dog feces.

Sources:
Probable – Wildlife (deer, raccoons, birds and pelicans),
Potential – Non-specific source (human waste), cats and dogs, gulls (secondary wildlife)
Possible –

19 - Sewage Exfiltration As a Source of Storm Drain Contamination during Dry Weather in Urban Watersheds

Bram Sercu

http://pubs.acs.org/doi/abs/10.1021/es200981k

Purpose - To determine whether transmission of sewage is occurring from leaking sanitary sewers directly to leaking separated storm drains, field experiments were performed in three watersheds in Santa Barbara, CA.

Results – Above-background RWT peaks were detected in storm drains in high-risk areas, and multiple locations of sewage contamination were found. Sewage contamination during the field studies was confirmed using the human-specific Bacteroidales HF183 and Methanobrevibacter smithii nifH DNA markers. This study is the first to provide direct evidence that leaking sanitary sewers can directly contaminate nearby leaking storm drains with untreated sewage during dry weather and suggests that chronic sanitary sewer leakage contributes to downstream fecal contamination of coastal beaches.

Sources:
Probable -
Potential -
Possible -

6 - Storm Drains are Sources of Human Fecal Pollution during Dry Weather in Three Urban Southern California Watersheds
Bram Sercu, L.C. Van de Werehorst, J. Murray, and P.A. Holden
http://www.santabarbaraca.gov/NR/rdonlyres/C3B1ADAE-37E8-4F89-8F2D-1A24FBAB8D6A/0/Sercuetal_ESnT_2009_v43p2938SI.pdf
Purpose - Dry weather bacteria monitoring in urbanized Santa Barbara, CA watersheds

Results - Of the 80 water samples analyzed within the Malibu watershed, five samples were positive for the human-specific HF183 Bacteroidales marker (HBM).The highest percent exceedance of FIB and HBM concentrations were measured during wet weather. During the study, 93.8% of the samples did not have detectable concentrations of HBM. These data do not rule out any particular potential sources of human fecal contamination.

Sources:
Probable -
Potential - Sewage infrastructure, non-stormwater discharges, MS4 infrastructure (less likely – human waste), MS4 infrastructure (anthropogenic non-human sources)
Possible -

116 - Identification of human fecal pollution sources in a coastal area: a case study at Oostende (Belgium)
Sylvie Seurinck, M. Verdievel, W. Verstraete, and S.D. Siciliano
http://www.iwaponline.com/jwh/004/0167/0040167.pdf
Purpose - Identify fecal pollution sources in the North Sea and produce a model required to predict fecal pollution

Results - The canal Gent-Oostende, the Dode Kreek and Gauwelozekreek, the Voorhaven, and the Montgommerydok contained high levels of the indicator bacteria. The European E. coli standard (5 £ 102/ 100 ml) suggested in the revised draft Bathing Water Directive (Council of the European Communities 2000) was exceeded most of the time at these sites. The human specific Bacteroides marker was detected in almost all water samples from these sites, which indicates that they are regularly contaminated with human fecal pollution. The river Noordede, the Visserijdok and the beach water at 2 sites were only lightly contaminated based on the European E. coli standard. At these sampling sites the human-specific Bacteroides marker was less frequently detected and in lower amounts, except at one locations where high concentrations of 107 human-specific Bacteroides marker per l were recorded at the beginning of the sampling survey and at the end. The detection of indicator organisms and the human specific Bacteroides marker was strongly related to rainfall for this coastal area.

Sources:
Probable – Non-specific sources (human waste)
Potential –Wildlife (non-anthropogenic)
Possible –

11 - Regrowth of Enterococci & Fecal Coliform in Biofilm. Printed in The Journal for Surface Water
John F. Skinner, J. Guzman, and J. Kappeler
Purpose - The goal of the study was to determine the sources of high numbers of enterococci and fecal coliform found in street gutter runoff flowing from residential areas to the Dover Drive storm drain in Newport Beach, Orange County

Results – Bacteria counts in runoff from washing the sidewalk using bacteria-free hose water were 220 enterococci/100 ml and 180 fecal coliform/100 ml. Washoff water from the driveway by manually flooding a residential front lawn was 160 enterococci/100 ml and 9 fecal coliform/100 ml. Runoff from flooding the grass contained 1,250 enterococci/100 ml and 2,000 fecal coliform/100 ml. Water draining directly into the gutter through a hole cut through the curb grew out 70 enterococci/100 ml and 100 fecal coliform/100 ml.

Bacteria-free hose water was introduced into a dry street gutter and tested for enterococci and fecal coliform at 10 meters, 45 meters, and 100 meters downstream when the flow from the hose water reached those locations. There was a progressive rise of both enterococci and fecal coliform bacteria with the increased distance of flow. The levels of fecal indicator bacteria were 26,000 enterococci/100 ml and 14,000 fecal coliform/100 ml when the water reached the 100-meter test site, the last testing station. The source of these high numbers of bacteria is suspected to be coming from regrowth in the street gutters.

The findings of these studies provide evidence that regrowth of both enterococci and fecal coliform bacteria are occurring in biofilm located in residential street gutters and storm drains in Newport Beach.

Sources:
Probable - Street gutter biofilm regrowth (MS4 infrastructure)
Potential – Dog excrement (not tested), lawn irrigation runoff, sidewalk and driveway runoff (Solid/liquid waste), residential washwater, residential lawn runoff
Possible - Residential backyard and side yard patios, roof gutter drains but not tested

49 - F+ RNA Coliphages as Source Tracking Viral Indicators of Fecal Contamination
Dr. Mark D. Sobsey, D.C. Love, and G.L. Lovelace
http://webmail.ciceet.unh.edu/news/releases/springReports07/pdf/sobsey.pdf
Purpose - To evaluate and apply novel, cost-effective technologies and methods for the detection, quantification and identification of sources of microbial contaminants and the characterization of those sources as human or nonhuman.

Results - Microbial indicator concentrations in water and shellfish were higher at sites with greater wastewater treatment plant discharges. Of the 9 estuaries in the study, 4 were impacted by point source discharges of waste water treatment plant (WWTP) effluent. Human point source pollution in this study was primarily from waste water treatment plant (WWTP) treated effluent and possibly raw sewage leaks, while likely human non-point sources included urban runoff, seepage from septic tanks, and boat dumping. Sites with non-human non-point fecal waste contained populations of wildfowl (goose, duck, gull), wild horses, other feral animals, agricultural animals, a dog park and urban pet waste. At 4 estuaries the impacted sites included human point and non-point sources, while the non-impacted sites were pristine sites with wildlife refuges or were geographically separated from human populations. In the Tijuana River Reserve in Southern CA human impacts were documented at all study sites, so in the absence of a truly pristine or non-impacted site, a site with only non-point source runoff from human development was compared to a more contaminated site at the mouth of the Tijuana River containing untreated sewage from Mexico.

Sources:
Probable -
Potential – Sewage infrastructure, Urban runoff (MS4 infrastructure - human waste; suspected to potential)
Possible -

45 - Faecal sterols analysis for the identification of human faecal pollution in a non-sewered catchment.
D. Sullivan, P. Brooks, N. Tindale, S. Chapman, and Ahmed, W.
http://publicationslist.org/data/w.ahmed/ref-14/Daryle_s%20article_%20WST_revised%20version.pdf
Purpose - To identify human faecal pollution in a non-sewered catchment using faecal sterols.

Results - In this study, faecal sterol analysis was used to identify the presence of human sourced faecal pollution or others (non-point sources) in two adjacent creeks of North Maroochy Catchment. It appears that stanols concentrations generally increased with increased catchment runoff. After moderate rainfall, high coprostanols levels found in water samples indicated human faecal pollution and defective septic systems are the most likely sources of pollution. The human signal was traced on one occasion to a defective septic system. In contrast, it appears that during dry weather human faecal pollution is not occurring in the study catchment.

Sources:
Probable – Septic (sewage infrastructure),
Potential –
Possible -

124 - Ecological Control of Fecal Indicator Bacteria in an Urban Stream
Cristiane Q. Surbeck, S.C. Jiang, and S.B. Grant
http://lshs.tamu.edu/docs/lshs/end-notes/ecological%20control%20of%20fecal%20indicator%20bacteria%20in%20an%20urban%20stream-1429959691/ecological%20control%20of%20fecal%20indicator%20bacteria%20in%20an%20urban%20stream.pdf

Purpose - Determine the source(s) of elevated FIB concentrations in Cucamonga Creek, a concrete-lined urban stream in southern California. Flow in the creek consists primarily of treated and disinfected wastewater effluent, mixed with relatively smaller but variable flow of runoff from the surrounding urban landscape.

Results - Mass and volume balance calculations indicate that treated wastewater is not a significant source of FIB to Cucamonga Creek. Runoff from the urban landscape appears to be the primary source of FIB loading to Cucamonga Creek during both dry weather and wet weather periods. Observations from the study imply that DOC and FIB concentrations in runoff should co-vary, which is indeed the case both at Cucamonga Creek and in many agricultural and urban streams along the California coast. These results are not consistent with the hypothesis that FIB are static contaminants (like sediments or nutrients) with well-defined and land-use-specific export coefficients, as has been suggested for catchments in the United Kingdom. Rather, our data suggest that nonpoint source FIB impairments in southern California are best viewed as an ecological phenomenon, in which a dynamic balance between FIB sources, nutrient availability, competition with other heterotrophic bacteria, and predator prevalence determines the magnitude and extent of FIB pollution and its human health implications.

Sources:
Probable – Non-specific Source (Human Waste), Domestic animals (dogs), Secondary Wildlife (birds)
Potential –
Possible -

50 - B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek Storm Drain Characterization Study

Tetra Tech, City of San Diego

Purpose - To further characterize the City's storm drain system discharges during both wet and dry weather. This monitoring program evaluated the potential sources of the pollutants-of-concern (POCs) throughout the MS4 system and collected data to calibrate and validate preliminary wet weather runoff modeling efforts for the San Diego Bay TMDLs.

Results - Bacteria concentrations from residential land use site DBR01 are higher than commercial land use site DBC02. The differences in bacteria concentrations across land use sampling sites were compared using t-test or Mann- Whitney Rank Sum test if data do not meet normality test. The results suggested significant difference in concentrations between the two sampling sites for both events and for all three microbiological parameters. Higher concentrations were found at the residential site (DBR01) than the commercial land use site (DBC02).

Sources:
Probable – Residential (Land use)
Potential – Commercial (Land use)
Possible -

53 - Chollas Storm Drain Characterization Study
Tetra Tech, City of San Diego
Purpose - To further characterize the City's storm drain system discharges during both wet and dry weather. This monitoring program evaluated the potential sources of the pollutants-of-concern (POCs) throughout the MS4 system and collected data to calibrate and validate preliminary wet weather runoff modeling efforts for the San Diego Bay TMDLs.

Results - The measured enterococcus and coliform concentrations generally showed large variations. The enterococcus concentrations showed a number of exceedances of the basin action level at a number of sites including several commercial and industrial sites and two residential sites. Fecal coliform concentrations were generally below action levels, with a few industrial and residential sites showing some exceedances. Total coliform concentrations showed a large number of exceedances at seven out of the ten sampling sites. The difference in bacteria concentrations across land use sampling sites was compared based on median concentrations and using the Mann-Whitney Rank Sum test (Table 7-4). The results suggested significant difference in concentrations among the sampling sites for both events and for all three microbiological parameters. Higher concentrations were found at two commercial (CHC07 and CHC12), industrial (CHI08) and two residential sites (CHR03 and CHR04).

Sources:
Probable – Commercial/Industrial (anthropogenic non-human sources; potential to probable), Commercial and industrial (land use)
Potential – Residential (land use)
Possible -

9 - Using Microbial Source Tracking to Support TMDL Development and Implementation
Tetra Tech, Inc. and Herrera Environmental Consultants
Purpose - Provides an overview of Microbial Source Tracking (MST) and how it can be used to support TMDL development and implementation. The document covers potential uses of MST, descriptions of common MST methods, factors for selecting an MST method and designing an MST study, and examples of MST studies used to support TMDL development or implementation.

Results – ID Study: The Bacteroides PCR results generally supported the PFGE results that wildlife was the predominant source of fecal bacteria in the sampled streams. The genetic fingerprinting showed that greater than 10 percent of the total E. coli colonies isolated were from dogs, and cats were almost 20 percent. In addition, there were two days on lower Hauser Creek when Idaho's primary contact water quality criterion for E. coli was exceeded, during which dogs were the source of over 40 percent of the isolates. Horses and cattle each did not exceed 10 percent of the total E. coli isolates; however, horses were greater than 15 percent of the E. coli isolates. Although humans made up 11 percent of the total E. coli colonies isolated on Right Fork Hauser Creek, only one E. coli colony was isolated from water samples collected on days when the water quality criterion was exceeded.

OR: Results indicated widespread contamination from ruminants (non-elk) and, in certain river segments of the Trask, Miami, and Tillamook Rivers and Holden Creek, significant contamination from humans.

NM: Overall, ribotyping results show the largest fraction of E. coli matched those found in avian sources, followed by canine, human/sewage, rodents, bovine, and equine. The source of approximately 9 percent of the E. coli could not be identified.

VA: MST Results indicate majority of sources derive from wildlife and livestock, followed by humans, and then pets.

NH: Ribotyping identified source species for 76% (19/25) of the E. coli isolates in the water samples. The remaining isolates (24%) could not be matched with certainty to patterns in the ribopattern database. Of the identified isolates, geese constituted the largest portion (52%) followed by livestock [sheep (12%) and cows (4%) for a total of 16%] and dogs (8%).

MI: During dry conditions, the human biomarker was present at all sites, except one site. The results were always negative for the human biomarker, giving a strong indication that E. coli from human sources was not impacting this site during dry conditions. Positive results for the other sites suggest that there are dry-weather sources of E. coli of human origin. These human sources of E. coli could include cross-connections between the sanitary and storm sewer systems, illicit discharges to storm sewers, failed on-site sewage disposal systems, and leaking sanitary sewers.

SD: Among the isolates for which the source could be identified, 26% were equine (horse) and 30% were ovine (sheep). Other identified animal sources include porcine (pig), bovine (cow), canine (dog), feline (cat) and human. Based on review of available information and communication with state and local authorities, the primary nonpoint sources of fecal coliform within the Beaver Creek watershed include agricultural runoff, as well as wildlife and human sources. Septic systems are assumed to be the primary human source of bacteria loads to Beaver Creek. The HSPF model was used to determine the contribution of fecal coliform bacteria from identified sources in the Beaver Creek watershed and evaluate the implementation of BMPs to control these sources.

Sources:
Probable – Geese (NH), avian (NM)
Potential – Non-specific source (human waste – NM, OR), sewage infrastructure (MI), illegal connections, domestic animals (NH, ID, NM), agriculture (OR), secondary wildlife (ID)
Possible -

37 - Monitoring Report for Bacterial Source Tracking Segments 0806, 0841, and 0805 of the Trinity River Bacteria TMDL
Texas Institute for Applied Environmental Research (TIAER)
http://repositories1.lib.utexas.edu/bitstream/handle/2152/7038/crwr_onlinereport08-08.pdf?sequence=2

Purpose - This report includes information on study area, characteristics, materials and methods of bacterial source tracking, and results and findings of the source tracking study.

Results – Overall, each of the source contributors showed a definite trend, whether positive or negative, as one moves downstream from Segment 0806, through Segment 0841, and into Segment 0805. The categories did show consistencies in source species. The avian category was consistently dominated by non waterfowl species, while the livestock category's contribution was shared by bovine and horses. Mammalian wildlife was found to be high in rodent species and raccoons, while the pet category was found to be consistently led by dogs.

Sources:
Probable – Non-specific source (human waste – potential to probable)
Potential - Pets and livestock, avian and mammals (wildlife)
Possible -

149 - Assessment of the Origins of Microbiological Contamination of Groundwater at a Rural Watershed in Chile
Mariela Valenzuela, M.A. Mondaca, M. Claret, C. Perez, B. Lagos, and O. Parra
http://www.scielo.org.mx/pdf/agro/v43n4/v43n4a10.pdf
Purpose - To improve the state of knowledge on the microbiological quality of groundwater at a rural watershed. Characterize the microbiological quality of the groundwater and to identify sources of contamination.

Results - The main source of fecal contamination is of animal origin, a diffuse one. Concentrations of bacterial indicators have a temporal basis showing variable levels among seasons, with a higher concentration in the rainy one. All 42 wells analyzed contained opportunistic pathogens.

167 - Bacterial pathogens in Hawaiian coastal streams-Associations with fecal indicators, land cover, and water quality
E.J. Viau, K.D. Goodwin, K.M. Yamahara, B.A. Layton, L.M. Sassoubre, S.L. Burns, H.I. Tong, S.H. Wong, and A.B. Boehm
http://www.sciencedirect.com/science/article/pii/S0043135411001448
Purpose - To understand the distribution of five bacterial pathogens in O'ahu coastal streams and relate their presence to microbial indicator concentrations, land cover of the surrounding watersheds, and physical-chemical measures of stream water quality.

Results - Results implicate streams as a source of pathogens to coastal waters. Future work is recommended to determine infectious risks of recreational waterborne illness related to O'ahu stream exposures and to mitigate these risks through control of land-based runoff sources.

146 - EFFECTS OF RUNOFF CONTROLS ON THE QUANTITY AND QUALITY OF URBAN RUNOFF AT TWO LOCATIONS IN AUSTIN, TEXAS

Clarence T. Welborn, and J.E. Veenhuis
http://pubs.usgs.gov/wri/1987/4004/report.pdf
Purpose - Determine if the rapid urban development in the Austin metropolitan area is causing an increase in the peak discharges from storm runoff and the degradation of the quality in receiving waters.

Results - Loads of most constituents and total densities of bacteria at the mall site were substantially larger in the inflow than in the outflow. The total densities of bacteria at the outflow were less by about 80 percent. Discharge weighted concentration data for Alta Vista indicate that the grass-covered swales and the grass-covered detention area had little or no effects on reducing concentrations or densities of most water-quality constituents.

Sources:
Probable – Residential, Industrial and Commercial Land Use(street, lawn and parking lot runoff)
Potential -
Possible -

14 - Tecolote Creek Microbial Source Tracking Summary Phases I, II, and III
Weston Solutions
Purpose - To investigate the bacterial sources, origins, and loads in the Tecolote Creek watershed and to assess and characterize specific priority activity contributions.

Results – Wet weather bacteria loads from individual land uses indicated that there were no significant differences between different land uses with flows merging and combining throughout drainage areas. There was some indication that higher loads were attributable to transportation corridors, commercial areas, and industrial land uses. Dry weather loads were higher in residential and commercial areas with specific activities identified as including poorly maintained dumpsters leaking high concentrations of indicator bacteria. A key transport mechanism found especially in commercial and industrial areas was over-irrigation. Residential areas were found to be abiding by water conservation recommendations, but this was not seen in commercial and industrial areas.

During dry weather, five positive Bacteroides samples were obtained. Each follow-up investigation failed to locate a point source; however, in every instance there was evidence of transient human activity. During wet weather, only 1 sample from a total of 37 samples collected over 9 storms was found to be positive for Bacteroides. This sample was collected during the early phase of the storm flows in an area known to be a transient area.

Biofilms on the walls of the MS4 system in particular were found to grow rapidly and contain high numbers of enterococci. Speciation of these enterococci determined that the origins were most likely environmental rather than fecal. Further investigation determined that the storm water, with high numbers of enterococci of fecal origin, was the primary inoculation mechanism but that biofilms matured rapidly into complex communities with a variety of species present. The high flows generated during wet weather were found to cause significant biofilm sloughing. The impact of biofilms on wet weather loads of indicator bacteria into receiving waters would appear to be significant. Sediments and biofilms within the creek and MS4 system were found to be significant reservoirs.

Sources:
Probable - Biofilm (MS4 Infrastructure), Sediment and biofilms in Tecolote Creek, Sediment and biofilms in MS4 Infrastructure
Potential - MS4 Infrastructure (anthropogenic non-human sources) Land use (residential, commercial, schools, restaurants, nurseries, golf course, livestock & domestic animal, industrial, Open space/Parks/Recreation, transportation corridors)
Possible -

52 - Dry Weather Bacterial Source Identification Study in the Mouth of Chollas Creek
Weston Solutions and the City of San Diego
Purpose - 1. What are the sources and magnitudes of dry weather urban runoff and associated indicator bacteria that influence water quality at the mouth of Chollas Creek?
2. What BMPs may be put in place to reduce or eliminate the influence of dry weather urban runoff at the mouth of Chollas Creek?

Results - During dry weather, there is no hydrologic connection between the mouth of Chollas Creek (the area influenced by tidal action) and the upstream drainage. Thus, bacteria found in the receiving waters of the creek mouth originate from sources that discharge directly to the mouth (i.e., storm drains). The highest bacterial concentrations were associated with the two storm drains near the National Avenue Bridge. Concentrations of indicator bacteria associated with the other identified storm drains were lower, but still contributed to elevated concentrations in the receiving water in the south fork and main stem, respectively. Two sources of flow that contributed to the high bacterial concentrations were identified as (1) over-irrigation of landscaping at the strip mall located at National Avenue and 35th Street and (2) a freshwater slough adjacent to a freeway off ramp that periodically discharges to a storm drain in the south fork of the creek.

Sources:
Probable - Storm drains and scour ponds at storm drain outlet; MS4 infrastructure; human waste), over-irrigation (landscaping)
Potential – Non-specific source (Freshwater slough; non-anthropogenic)
Possible -

54 - Regional Harbor Monitoring Program Pilot Project 2005-08 Summary Final Report
Weston Solutions and the City of San Diego
Purpose - The core monitoring program assesses the conditions found in the harbors based on comparisons to historical reference values for the four harbors and comparisons of contaminant concentrations to known surface water and sediment thresholds using chemistry, bacterial, toxicology, and benthic infaunal community indicators.
Results - Based on the results of the Pilot Project, the following statements can be made: 1) All bacterial concentrations were well below AB 411 levels, 2) The majorities of the marina and

freshwater-influenced strata contained sediments that were not toxic, 3) Benthic infaunal communities in both strata occurred at intermediate levels of disturbance, 4) Toxicity levels in the marina sediments generally were better than harbor-wide historical conditions, 5) Toxicity levels and benthic infaunal communities did not differ between the two strata, and 6) From 2005-2007, no negative short-term trends were evident for any indicator that would be indicative of a degrading condition.

70 - 2009-2010 Coastal Storm Drain Monitoring Annual Report
Weston Solutions, Inc. and County of San Diego Copermittees
Purpose - To determine the impacts that storm drains have on coastal receiving waters.

Results - There were a total of 28 exceedances of the total coliform storm drain action level. Twelve sites had at least one exceedance for total coliform, of which 3 had a total coliform exceedance on multiple dates.

Sources:
Probable – Cats
Potential –Cows, horses, fox, cormorants,
Possible – Non-specific source (human waste), gulls (secondary wildlife), Wildlife (muskrats, raccoons, coyotes, rabbits, turkeys and geese)

74 - MICROBIAL SOURCE TRACKING IN TWO SOUTHERN MAINE WATERSHEDS Report Number: MSG-TR-04-03March 2004Merriland River, Branch Brook and Little River (MBLR) Watershed Report
Kristen Whiting-Grant, F. Dillon, C. Dalton, Dr. M. Dionne, and Dr. S. Jones
Purpose - This study focuses on the Merriland River, Branch Brook and Little River (MBLR) watershed in Wells, Kennebunk and Sanford Maine, where chronic and persistent bacterial contamination from unidentified sources has restricted shellfish harvesting.

Results - Cats were the most frequently identified single source of bacterial contamination (21%); followed by cow (11%); fox (7%); cormorant (5%); human, rabbit, muskrat, horse and gull (all at3%); turkey (2%); and goose, raccoon, coyote and dog (all at 1%). Also note that ribotypes for 35% of the bacteria samples analyzed by JEL could not be identified, which is to say that no clear matches could be established between ribotypes of known source species and ribotypes from unknown water samples.

Sources:
Probable – Cats
Potential –Cows, horses, fox, cormorants,
Possible – Non-specific source (human waste), gulls (secondary wildlife), Wildlife (muskrats, raccoons, coyotes, rabbits, turkeys and geese)

64 - Microbial Source Tracking in the Dungeness Watershed, Washington
D.L. Woodruff, N.K. Sather, V.I. Cullinan, and S.L. Sargeant
Purpose - To determine the sources of fecal coliform pollution that have been impacting the water quality and shellfish harvesting activities for more than a decade.

Results – The predominant sources of fecal coliform contamination in the Dungeness from all matrix types (e.g. water, sediment, wrack) in the freshwater and marine environments were, in rank order, avian (19.6%), gull (12.5%), waterfowl (9.7%), raccoon (9.2%), unknown (7.3%), human-derived (7.1%), rodent (6.3%) and dog (4.3%). When bird groups were combined, they represented in total about 42% of samples collected and analyzed throughout the study.

Sources:
Probable – Wildlife,
Potential - Non-specific source (human waste), domestic animals,
Possible -

44 - Quantitative Pathogen Detection and MST Combined with modeling of fate and transport of Bacteroidales in San Pablo Bay.
Stefan Wuertz, F. Bombardelli, K. Sirikanchana, A. Schriewer, and Z. Kaveh
Purpose - To develop a decision-making took in the form of a 3-D model to benefit coastal managers both in terms of pinpointing major sources of fecal pollution and maximizing the usefulness of any monitoring activity.

Results – Monitoring results indicated low-level general and human-derived fecal contamination in the bay, while cow- and dog-derived contamination was not detected, except for one sample which contained dog-specific genetic marker. Human viruses were also below the sample detection limit. The pollution was more likely to come from surrounding urban areas or wastewater treatment facilities than from agricultural farm land or wildlife areas.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible – Dogs and cows

232 - Indicator organism sources and coastal water quality: a catchment study on the island of Jersey
M.D. Wyer, D. Kay, G.F. Jackson, H.M. Dawson, J. Yeo, and L. Tanguy
http://www.ncbi.nlm.nih.gov/pubmed/7730205
Purpose - Compliance monitoring of bathing waters at La Grève de Lecq on the North coast of Jersey revealed a significant deterioration in water quality between 1992 and 1993, as indexed by presumptive coliform, presumptive Escherichia coli and streptococci concentrations. During the 1993 bathing season the beach failed to attain the compliance with the EC Guideline criteria for presumptive E. coli and streptococci.

Results - A bacteriological survey of the stream catchment draining to the beach revealed that: (i) concentrations of faecal indicator organisms were enhanced at high discharge after rainfall; and (ii) a captive water fowl population, which expanded between 1990 and 1993, was a potential source of faecal pollution.

233 - Beach sands along the California coast are diffuse sources of fecal bacteria to coastal waters

K.M. Yamahara, B.A. Layton, A.E. Santoro, and A.B. Boehm

http://pubs.acs.org/doi/abs/10.1021/es062822n

Purpose - The potential for FIB to be transported from the sand to sea was investigated at a single wave-sheltered beach with high densities of ENT in beach sand

Results - We collected samples of exposed and submerged sands as well as water over a 24 h period in order to compare the disappearance or appearance of ENT in sand and the water column. Exposed sands had significantly higher densities of ENT than submerged sands with the highest densities located near the high tide line. Water column ENT densities began low, increased sharply during the first flood tide and slowly decreased over the remainder of the study. During the first flood tide, the number of ENT that entered the water column was nearly equivalent to the number of ENT lost from exposed sands when they were submerged by seawater. The decrease in nearshore ENT concentrations after the initial influx can be explained by ENT die-off and dilution with clean ocean water. While some ENT in the water and sand at LP might be of human origin because they were positive for the esp gene, others lacked the esp gene and were therefore equivocal with respect to their origin.

58 - High-Throughput and Quantitative Procedure for Determining Sources of Escherichia coli in Waterways by Using Host-Specific DNA Marker Genes

Tao Yan, M.J. Hamilton, and M.J. Sadowsky

http://aem.asm.org/content/73/3/890.full.pdf+html

Purpose - The objective of the study was to evaluate a high-throughput, semi-automated, quantitative procedure for determining sources of *E. coli* in waterways by using host-specific DNA marker genes of geese and ducks and robot-assisted high-throughput technology. Although the objective was to evaluate the method, the seasonal goose/duck population as a bacteria source was evaluated at 2 lakes frequented with migratory goose/duck populations and an additional lake that is not frequented by migratory goose

Results - The relative contributions of fecal *E.coli* from the geese/ducks were estimated to be 34% and 51% in Lake Superior and Lake Calhoun, respectively and 0.28% at Lake Hartwell (which has no migratory goose population)

Sources:
Probable – Wildlife (Lake Calhoun, Lake Superior),
Potential -
Possible–Wildlife (Lake Hartwell which has no migratory goose populations)

NSC (Not Source Characterization) Studies

137 - Relationship between rainfall and beach bacterial concentrations on Santa Monica Bay beaches
Drew Ackerman and S. B. Weisberg
http://www.sccwrp.org:8060/pub/download/DOCUMENTS/AnnualReports/2001_02AnnualReport/18_ar37-drew.pdf
Purpose - To enhance the scientific foundation for preemptive public health warnings, examine the relationship between rainfall and beach indicator bacteria concentrations using five years of fecal coliform data taken daily at 20 sites in southern California.

Results - There was a clear relationship between the incidence of rainfall and reduction in beach bacterial water quality in Los Angeles County. Bacterial concentrations remained elevated for five days following a storm, although they generally returned to levels below state water quality standards within three days. The length of the antecedent dry period had a minimal effect on this relationship, probably reflecting a quickly developing equilibrium between the decay of older fecal material and the introduction of new fecal material to the landscape.

175 - Persistence and potential growth of the fecal indicator bacteria, Escherichia coli in shoreline sand at Lake Huron
E.W. Alm, J. Burke, and E. Hagan
http://www.bioone.org/doi/abs/10.3394/0380-1330%282006%2932%5B401:PAPGOT%5D2.0.CO;2
Purpose - This study was initiated to test the hypothesis that high abundances of the fecal indicator Escherichia coli in shoreline sand at freshwater beaches can be explained, at least in part, by the ability of E. coli to persist and grow in beach sand.

Results - In controlled laboratory microcosm studies using autoclaved beach sand inoculated with E. coli strains previously isolated from ambient beach sand, E. coli densities increased from 2 CFU/g to more than 2 × 105 CFU/g sand after 2 days of incubation at 19°C, and remained above 2 × 105 CFU/g for at least 35 days. In field studies utilizing similarly inoculated beach sand in diffusion chambers incubated at a Lake Huron beach, E. coli also grew rapidly, reaching high densities (approximately 7.5 × 105 CFU/g), and persisting in a cultivable state at high density for at least 48 days. In comparison, E. coli levels in ambient beach sand adjacent to the chambers always had densities <100 CFU/g. Lake Huron beach sand clearly provides nutrients, temperatures, and other conditions needed to support growth of E. coli. The growth of E. coli in sterile sand diffusion chambers to higher levels than occurs in ambient beach sand may indicate the presence in ambient sand of biological controls on bacterial growth, such as predation or competition.

59 - Host Species-Specific Metabolic Fingerprint Database for Enterococci and Escherichia coli and Its Application to Identify Sources of Fecal Contamination in Surface Waters
Warish Ahmed, R. Neller, and M. Katoulli
http://aem.asm.org/content/71/8/4461.full.pdf+html

Purpose - To characterize two fecal indicator bacteria, enterococci and E. coli, from different host groups (i.e., animal species) to develop a metabolic fingerprint database to identify the source(s) of fecal contamination in a creek in Australia.

Results - Out of 27 water samples:10% of the biochemical phenotypes (BPT) found for enterococci belonged to human origin, 61% belonged to animals tested. 13% of the BPTs found for E. coli belonged to human origin and 54% belonged to animals tested. The remaining BPT found for Enterococci and E. coli belonged to BPTs shared between humans and animals or did not match database

Sources:
Probable –Septic (human waste), animal farms (domestic animals), animal farms (agriculture),
Potential -
Possible -

80 - Persistence and Differential Survival of Fecal Indicator Bacteria in Subtropical Waters and Sediments
K.L. Anderson, J.E. Whitlock, and V.J. Harwood
http://aem.asm.org/content/71/6/3041.full.pdf+html
Purpose - Fecal coliforms and enterococci are indicator organisms used worldwide to monitor water quality. These bacteria are used in microbial source tracking (MST) studies, which attempt to assess the contribution of various host species to fecal pollution in water. Ideally, all strains of a given indicator organism (IO) would experience equal persistence (maintenance of culturable populations) in water; however, some strains may have comparatively extended persistence outside the host, while others may persist very poorly in environmental waters. Assessment of the relative contribution of host species to fecal pollution would be confounded by differential persistence of strains.

Results - IO persistence according to mesocosm treatment followed the trend: contaminated soil > wastewater > dog feces. E. coli ribotyping demonstrated that certain strains were more persistent than others in freshwater mesocosms, and the distribution of ribotypes sampled from mesocosm waters was dissimilar from the distribution in fecal material. These results have implications for the accuracy of MST methods, modeling of microbial populations in water, and efficacy of regulatory standards for protection of water quality. Saltwater had a negative effect on FC persistence, as the decay rates of FC (all inoculum sources combined) in saltwater sediments and water column were greater than those in freshwater. Saltwater also significantly increased enterococcal decay rates compared to freshwater. IO persistence tended to be greater in sediments than in the water column. The average decay rate of FC in sediments of freshwater mesocosms was significantly less than those in the water column, and the difference was nearly significantly at the $\alpha = 0.05$ level in saltwater ($P = 0.083$). Although decay rates of enterococci tended to be greater in the water column than in sediments, the difference was not significant in freshwater or saltwater mesocosms.

176 - Persistence and differential survival of fecal indicator bacteria in subtropical waters and sediments
K.L. Anderson, J.E. Whitlock, and V.J. Harwood
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1151827/
Purpose - This study utilized mesocosms designed to simulate natural conditions, which were inoculated with fecal material, to test the hypothesis that certain *E. coli* phylotypes exhibit greater persistence than others in aquatic environments.

Results - This study demonstrated a high degree of variability in the response of fecal indicator organisms to stresses in aquatic environments on all levels investigated. Responses to water type (saline versus fresh), location (sediment versus water column), and inoculum type all varied within and between indicator bacterial groups (FC and ENT). The discrepant results emphasize the difficulties encountered in attempting to regulate diverse types of water bodies by one regulatory standard. Also cautionary is the persistence of indicator organisms in sediments, which leads to elevation of their densities and a false indication of recent pollution in the water column after events such as rain storms, construction, or recreational use.

130 - LEVELS OF FECAL INDICATOR BACTERIA AT DOG BEACH AND NEARBY COASTAL BEACHES OF THE CITY OF SAN DIEGO, CA
Amir Baum
http://www.sandiegoriver.org/documents/baum_final_thesis.pdf
Purpose - An analysis of historical County of San Diego microbial marine water quality was conducted to quantitatively compare the levels of fecal indicator bacteria (FIB) levels at Dog Beach, located at the San Diego River Outlet, and nearby coastal beaches. Additionally, this study aimed to determine if relationships existed between daily average river flow/daily precipitation and FIB densities at Dog Beach and nearby coastal beach stations and if significant associations existed between daily precipitation and FIB single sample exceedances.

Results - The study found the strongest association between river flow, precipitation, and TC levels to be at river discharge points during wet months, but no significant association was found during dry weather. The study demonstrated that using a stratified-random sampling design, urban runoff outlets are a primary source of contaminated runoff with 90% of sites near urban runoff outlets failing water quality standards.

81 - Integrated Analysis of Established and Novel Microbial and Chemical Methods for Microbial Source Tracking
Anicet R. Blanch, L. Belanche-Muñoz, X. Bonjoch, J. Ebdon, C. Gantzer, F. Lucena, J. Ottoson, C. Kourtis, A. Iversen, I. Kühn, L. Mocé, M. Muniesa, J. Schwartzbrod, S. Skraber, G.T. Papageorgiou, H. Taylor, J. Wallis, and J. Jofre
http://aem.asm.org/content/72/9/5915.full.pdf+html
Purpose - The objectives of the present study were (i) to determine the most discriminant tracers showing wide and consistent geographical stability between all locations, (ii) to identify subsets of variables derived from tracers with the highest discriminant capacity, and (iii) to evaluate and

compare statistical or machine learning methods to develop predictive models for source tracking using the minimum number of these variables. In this multilaboratory study, different microbial and chemical indicators were analyzed in order to distinguish human fecal sources from nonhuman fecal sources using wastewaters and slurries from diverse geographical areas within Europe.

Results - Fecal coliforms, enterococci, clostridia, somatic coliphages, and total bifidobacteria were detected in almost all samples (other than a single sample in the case of total bifidobacteria) of both human and animal origin. They were more abundant in the animal samples than in the human samples, but this seems to be due to the higher fecal load of these samples, since relative densities were similar in both groups of samples.

21 - Enterococci Concentrations in Diverse Coastal Environments Exhibit Extreme Variability
A.R. Boehm
http://pubs.acs.org/doi/abs/10.1021/es071807v
Purpose - The study examines extreme temporal variations (periods between 1 min andZ4 h) in FIB concentrations in diverse marine coastal environments ranging from wave-sheltered to wave-exposed open ocean beaches.

Results - The high frequency variability indicates that regardless of sampling time, a single sample of water tells one little about the true water quality, so multiple samples need to be collected. If it is not feasible to collect multiple samples, then a spatially or temporally composited sample will improve the estimate of the true water quality.

157 - Methicillin-resistant Staphylococcus aureus (MRSA) in municipal wastewater: an uncharted threat?
S. Börjesson, A. Matussek, S. Melin, S. Löfgren, and P.E. Lindgren
http://www.mendeley.com/research/methicillinresistant-staphylococcus-aureus-mrsa-in-municipal-wastewater-an-uncharted-threat/#page-1
Purpose - (i) To cultivate methicillin-resistant Staphylococcus aureus (MRSA) from a full-scale wastewater treatment plant (WWTP), (ii) To characterize the indigenous MRSA-flora, (iii) To investigate how the treatment process affects clonal distribution and (iv) to examine the genetic relation between MRSA from wastewater and clinical MRSA.

Results - MRSA could be isolated on all sampling occasions, but only from inlet and activated sludge. The number of isolates and diversity of MRSA were reduced by the treatment process, but there are indications that the process was selected for strains with more extensive antibiotic resistance and PVL+ strains. The wastewater MRSA-flora had a close genetic relationship to clinical isolates, most likely reflecting carriage in the community.

158 - A seasonal study of the mecA gene and Staphylococcus aureus including methicillin-resistant S. aureus in a municipal wastewater treatment plant
S. Börjesson, S. Melin, A. Matussek, and P.E. Lindgren
http://www.loudounnats.org/pdf/09WRAseasonalstudyofmecASaureusandMRSAinafull-scaleWWTP.pdf
Purpose - Determine the effect of wastewater treatment processes on mecA gene concentrations, and the prevalence of S. aureus and MRSA over time. To achieve this a municipal wastewater treatment plant was investigated for the mecA gene, S. aureus and MRSA, using real-time PCR assays

Results - Using molecular methods and cultivation, MRSA was for the first time detected in a municipal activated sludge and trickling filter WWTP, but mainly in the early treatment steps, IN, PS and AS. The mecA gene and S. aureus could be detected throughout the year at all sampling sites. The wastewater treatment process reduces mecA gene concentrations, which can partly be explained by removal of biomass.

140 - Particle Associated Microorganisms in Stormwater Runoff
Michael Borst, and A. Selvakumar
http://www.epa.gov/ORD/NRMRL/pubs/600j03262/600j03262.pdf
Purpose - Investigate the effects of blending and chemical addition before analysis of the concentration of microorganisms in stormwater runoff play a significant role.

Results - Particle-associated microorganisms play an important, if often unmeasured, portion of the total organism count in stormwater. All organisms, except for E. coli, showed an increase in the measured concentration after blending samples at 22,000 rpm with or without the chemical mixture. Other than fecal streptococci, the organism concentrations decreased with the addition of the Camper's solution in both blended and unblended samples before analyses. There was a statistically significant interaction between the effects of Camper's solution and the effects of blending for all the organisms tested, except for total coliform. Blending did not alter the mean particle size significantly. The results show no correlation between increased total coliform, fecal coliform, and fecal streptococcus concentrations and the mean particle size.

87 - Direct comparison of four bacterial source tracking methods and use of composite data sets
E.A. Casarez, S.D. Pillai, J.B. Mott, M. Vargas, K.E. Dean and G.D. Di Giovanni
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2006.03246.x/pdf
Purpose - (i) To compare the identification ability of the four BST methods individually and in combination through the use of composite data sets and (ii) to evaluate the use of the developed data sets for the identification of faecal contamination sources in two Central Texas lakes suspected of being impacted by agricultural operations and dairy cattle.

Results - Best matching identification using the composite data set correctly identified 100% of the replicate QC cultures (precision), and had 100% accuracy for E. coli strain and source class identification of the isolates. Therefore, the four-method composite performed better than any single method.

154 - Removal of bacterial indicators of fecal contamination in urban stormwater using a natural riparian buffer
M.J. Casteel, G. Bartow, S.R. Taylor, and P. Sweetland
http://www.lmtf.org/FoLM/Plans/Water/VistaGrande/Casteeletal_10icud_paper.PDF
Purpose - Determine if riparian buffers are able to remove bacterial indicators of fecal contamination and other microbial contaminants from intermittent, high-volume flows such as those encountered during storm events in heavily urbanized areas.

Results - Analysis of lake water showed that levels of Escherichia coli and total coliforms increased significantly during storm events, indicating the presence of nonpoint sources of fecal contamination in the area surrounding the lake.

134 - Population structure and persistence of Escherichia coli in ditch sediments and water in the Seven Mile Creek Watershed
Ramyavardhanee Chandrasekaran
http://conservancy.umn.edu/bitstream/108879/1/Chandrasekaran_Ramyavardhanee_May2011.pdf
Purpose - Examined the population structure of E. coli and determined whether ditch sediments can serve as reservoirs of environmental E. coli in the Seven Mile Creek (SMC) watershed, a minor watershed located in south central Minnesota

Results - Further analysis of the count data revealed a strong correlation between E. coli concentrations and temperature profile at the SMC. E. coli densities in SMC water samples exceeded the permissible Minnesota standard (126 CFU/100 ml) predominantly during summer and fall seasons. In addition to temperature, rainfall also drastically influenced the dynamics and distribution of E. coli populations at the SMC. Results suggest that the seasonal variation in E. coli counts observed in water and sediments are most likely related to temperature, rainfall, and the patchy distribution of E. coli within sampling locations

88 - Relative Decay of Bacteroidales Microbial Source Tracking Markers and Cultivated Escherichia coli in Freshwater Microcosms
Linda K. Dick, Erin A. Stelzer, Erin E. Bertke, Denise L. Fong, and Donald M. Stoeckel
http://aem.asm.org/content/76/10/3255.full.pdf+html
Purpose - Fecal indicator bacteria (FIB), commonly used to regulate sanitary water quality, cannot discriminate among sources of contamination. The use of alternative quantitative PCR (qPCR) methods for monitoring fecal contamination or microbial source tracking requires an understanding of relationships with cultivate FIB, as contamination ages under various conditions in the environment. In this study, the decay rates of three Bacteroidales 16S rRNA gene markers (AllBac for general contamination and qHF183 and BacHum for human-associated contamination) were compared with the decay rate of cultivated Escherichia coli in river water microcosms spiked with human wastewater.

Results - A major finding of this study was that HF marker decay was consistent with, or significantly faster than, that of E. coli under all treatments. This indicates that the HF markers might be useful as conservative estimators of human origin E. coli even as fecal contamination ages in the environment.

118 - Bacteriological Quality of Runoff Water from Pastureland
J.W. Doran, and D.M. Linn
http://aem.asm.org/content/37/5/985.abstract
Purpose - Determine the bacteriological characteristics of pasture runoff and to compare them with runoff from an ungrazed area.

Results - We found no relationship between FC and FS counts in rainfall runoff and either rainfall or total runoff for most events. Bacteriological quality of snowmelt runoff. During the 3-year study, there were 10 snowmelt runoff events-two in 1976 and 8 in 1978. The levels of TC in snowmelt runoff from both grazed and ungrazed pasture areas exceeded recommended water quality standards . FC counts, often considered a better index of fecal contamination, were within recommended standards.

89 - Microbial source tracking using host specific FAME profiles of fecal coliforms
Metin Duran, Berat Z. Haznedaroglu, and Daniel H. Zitomer
http://www.prairieswine.com/pdf/3397.pdf
Purpose - The objective of this study was to investigate the host-specific differences in fatty acid methyl ester (FAME) profiles of fecal coliforms (FC).

Results - The results presented here provide further evidence that FAME profiles of indicator organisms have statistically significant host specificity and suggest that these differences may be useful in predicting sources of microbial pollution in water environments. However, more research is needed to determine the mechanisms causing the host specificity and to assess the possible temporal and spatial variations in FAME profiles before FAME can be applied in the field.

183 - Quantitative evaluation of enterococci and Bacteroidales released by adults and toddlers in marine water
S.M. Elmir, T. Shibata, H.M. Solo-Gabriele, C.D. Sinigalliano, M.L. Gidley, G. Miller, L.R.W. Plano, J. Kish, K. Withum, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2761526/
Purpose - The main objectives of the this study were to measure shedding of enterococci and Bacteroidales using traditional and emerging laboratory methods, and to evaluate shedding from toddlers and adults. The added value of the current study was the evaluation of shedding from toddlers (all prior studies used adult volunteers), and the use of additional methods of fecal indicator bacteria analyses (i.e. enterococci by CS and qPCR, and Bacteroidales by qPCR) as no data are available which directly measure fecal indicator bacteria shedding using these alternate methods.

Results - Human bathers have the potential to release significant amounts of fecal indicator bacteria into the water column via direct shedding off their body and via sand transported by their skin. Direct shedding from the body can include releases from fecally contaminated body areas and skin, and releases from fecally contaminated diapers. In this study, the quantity of enterococci released was a function of bathing cycle, sand exposure, beach sand contamination levels, and microbial flora variations between swimmers.

182 - Quantitative evaluation of bacteria released by bathers in a marine water
S.M Elmir, M.E. Wright, A. Abdelzaher, H.M. Solo-Gabriele, L.E. Fleming, G. Miller, M. Rybolowik, M.T. Peter Shih, S.P. Pillai, J.A. Cooper and E.A. Quaye
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2633726/
Purpose - This study focused on estimating the amounts of enterococci and S. aureus shed by bathers directly off their skin and indirectly via sand adhered to skin.

Results - This study demonstrated that bathers shed significant concentrations of enterococci and S. aureus into the water column and that S. aureus was shed at concentrations at least one order of magnitude greater than enterococci. This study also showed that total enterococci and S. aureus released by bathers decreased significantly between bathing episodes, in particular after the first wash cycle. This conclusion agrees with the long standing universal requirement that bathers should shower before entering recreational waters to reduce the microbial load in particular at swimming pools since the water volume is limited. It is concluded from this study that the enterococci contribution from sand adhered to skin, was small relative to the amount shed directly from the skin and represented less than 5% of the total enterococci shed by bathers.

159 - Staphylococcus aureus and fecal indicators in Egyptian coastal waters of Aqaba Gulf, Suez Gulf, and Red Sea
M.A. El-Shenawy
http://www.nodc-egypt.org/contacts_files/vol-31-2/Volume%2031%20%282%29%202005.PDF/9/Text.pdf
Purpose - Study the hygienic status of Egyptian coastal waters of Aqaba Gulf, Suez Gulf and Red Sea. The possibility of using *S.aureus* as supplementary indicator to the conventional bacterial indicators was another goal.

Results - 107 samples (53.5 %) of the 200 total examined samples were found to harbour S aureus exceeding the aforementioned guide standards. The present results concluded that addition of S. aureus as supplementary indicator to the conventional fecal indications may be useful for judging the marine water quality in Red Sea region.

138 - Sediment Bacterial Indicators in an Urban Shellfishing Subestuary of the Lower Chesapeake Bay
Carl W. Erkenbrecher Jr.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC244041/pdf/aem00190-0106.pdf

Purpose - Historically, the Lynnhaven, an urban shellfishing estuary of the lower Chesapeake Bay region, has been opened and closed periodically to shellfishing during the past 40 years due to high fecal coliform counts. Document the spatial and temporal distributions and compositions of bacteria in the sediments and overlying waters of an important urban shellfishing area in the lower Chesapeake Bay region, the Lynnhaven Estuary.

Results - Densities of all indicator bacteria were always significantly higher in the sediments than in the overlying subsurface waters. The major problems inherent in this system are nonpoint in their origin. The primary sources of the Lynnhaven's bacterial pollution appeared to be typical of urban and agricultural runoff, although failure of septic tank systems was suspected as a problem in the Lynnhaven's western branch. These results illustrated that sediments in shellfishing areas could serve as a reservoir for high densities of indicator bacteria and that, potentially, pathogens could pose a health hazard.

184 - Enumeration and speciation of enterococci found in marine and intertidal sediments and coastal water in southern California

D.M. Ferguson, D.F. Moore, M.A. Getrich, and M.H. Zhowandai

http://www.ochealthinfo.com/docs/public/h2o/Enumeration-speciation.pdf

Purpose - To determine the levels and species distribution of enterococci in intertidal and marine sediments and coastal waters at two beaches frequently in violation of bacterial water standards.

Results - High levels of Enterococcus in intertidal sediments indicate retention and possible regrowth in this environment. Significance and Impact of the Study: Re-suspension of enterococci that are persistent in sediments may cause beach water quality failures and calls into question the specificity of this indicator for determining recent faecal contamination.

90 - Comparison of Bacteroides-Prevotella 16S rRNA Genetic Markers for Fecal Samples from Different Animal Species

Lisa R. Fogarty and Mary A. Voytek

http://aem.asm.org/content/71/10/5999.full.pdf+html

Purpose - The goals of this study were to compare Bacteroides-Prevotella populations from nine host species collected at multiple geographical locations and to determine if unique populations could be identified for each host species that could be used to develop markers for fecal source tracking.

Results - Results support the use of molecular techniques to characterize Bacteroides-Prevotella populations as a means to improve the ability to track sources of fecal contamination, but also show the need for more development of these methods.

186 - Abundance and characteristics of the recreational water quality indicator bacteria Escherichia coli and enterococci in gull faeces

L.R. Fogarty, S.K. Haack, M.J. Wolcott, and R.L. Whitman

http://cws.msu.edu/documents/FogartyetalJAM2003.pdf

Purpose - To evaluate the numbers and selected phenotypic and genotypic characteristics of the faecal indicator bacteria Escherichia coli and enterococci in gull faeces at representative Great Lakes swimming beaches in the United States.

Results - Gull faeces could be a major contributor of E. coli (105–109 CFU g)1) and enterococci (104– 108 CFU g)1) to Great Lakes recreational waters. E. coli and enterococci in gull faeces are highly variable with respect to their genotypic and phenotypic characteristics and may exhibit temporal or geographic trends in these features.

162 - A preliminary investigation of fecal indicator bacteria, human pathogens, and source tracking markers in beach water and sand
K.D. Goodwin, L. Matragrano, D. Wanless, C. Sinigalliano, and M.J. LaGier
http://yyy.rsmas.miami.edu/groups/ohh/projects/microbesresearch/GoodwinERK2_4.pdf
Purpose - Data suggesting that fecal indicating bacteria may persist and/or regrow in sand has raised concerns that fecal indicators may become uncoupled from sources of human fecal pollution. To investigate this possibility, wet and dry beach sand, beach water, riverine water, canal water, and raw sewage samples were screened by PCR for certain pathogenic microbes and molecular markers of human fecal pollution.

Results - Overall, this analysis pointed to the need to find better methods of extracting nucleic acids from environmental samples in order to reduce the possibility of false negative results. High quality nucleic acids need to be consistently and efficiently delivered to the detector system if the relationship between fecal indicators and human pathogens and human source tracking markers is to be elucidated.

93 - Comparing Wastewater Chemicals, Indicator Bacteria Concentrations, and Bacterial Pathogen Genes as Fecal Pollution Indicators
Sheridan K. Haack, Joseph W. Duris, Lisa R. Fogarty, Dana W. Kolpin, Michael J. Focazio, Edward T. Furlong, and Michael T. Meyer
https://www.crops.org/publications/jeq/pdfs/38/1/248
Purpose - Compare fecal indicator bacteria (FIB) (fecal coliforms, Escherichia coli [EC], and enterococci [ENT]) concentrations with a wide array of typical organic wastewater chemicals and selected bacterial genes as indicators of fecal pollution in water samples collected at or near 18 surface water drinking water intakes.

Results - In our study, which examined ambient waters in various land use environments with a wide range of FIB concentrations, fecal pollution was indicated by gene-based and/or chemical-based markers for 14 of the 18 tested samples, with little relation to FIB standards.

95 - Development of Goose- and Duck-Specific DNA Markers To Determine Sources of Escherichia coli in Waterways
Matthew J. Hamilton, Tao Yan, and Michael J. Sadowsky
http://aem.asm.org/content/72/6/4012.full.pdf+html

Purpose - The development and validation of host source-specific genetic markers for E. coli strains originating from Canada geese (*Branta canadensis*).

Results - SSH was successfully used to identify seven DNA markers with high levels of hybridization specificity for E. coli strains originating from geese. Combined, the marker DNAs were capable of identifying about 76% of the goose E. coli strains examined and 73% of the duck E. coli strains examined.

192 - Waterfowl Abundance Does Not Predict the Dominant Avian Source of Beach Escherichia coli

D.L. Hansen, S. Ishii, M.J. Sadowsky, and R.E. Hicks

https://www.soils.org/publications/jeq/abstracts/40/6/1924?access=0&view=pdf

Purpose - The horizontal, fluorophore enhanced, rep-PCR (HFERP) DNA fingerprinting technique was used to identify potential sources of Escherichia coli in water, nearshore sand, and sediment at two beaches in the Duluth-Superior Harbor, near Duluth, MN, and Superior, WI, during May, July, and September 2006.

Results - Waterfowl, including Canada geese, ring-billed gulls, and mallard ducks, were the largest source of E. coli that could be identified in water (55–100%), sand (59–100%), and sediment (92–100%) at both beaches. Although ring-billed gulls were more abundant in this harbor, Canada geese were usually the dominant source of waterfowl E. coli found at these beaches.

96 - Validation and field testing of library-independent microbial source tracking methods in the Gulf of Mexico

Valerie J. Harwood, Miriam Brownell, Shiao Wang, Joe Lepo, R.D. Ellender, Abidemi Ajidahun, Kristen N. Hellein, Elizabeth Kennedy, Xunyan Ye, and Christopher Flood

http://www.usm.edu/bst/pdf/Water%20Res%202009.pdf

Purpose - Standardize and validate MST methods across laboratories in coastal Gulf of Mexico states.

Results - An SOP was developed that allowed simultaneous purification of DNA for viral and bacterial markers, and gave comparable results among three laboratories. The method performance was generally similar whether it was conducted in buffer, fresh water or salt water; however, the human Bacteroidales method had a lower limit of detection in buffer and in salt water compared to fresh water.

97 - Fidelity of bacterial source tracking: Escherichia coli vs. Enterococcus spp. and minimizing assignment of isolates from non-library sources

W.M. Hassan, R.D. Ellender and S.Y. Wang

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2006.03077.x/pdf

Purpose - Improve the fidelity of library-dependent bacterial source tracking efforts in determining sources of faecal pollution.

Results - The use of enterococci provides higher rates of correct source assignment compared with E. coli. The use of similarity thresholds to decide whether to accept source assignments made by computer programmes reduces the rate of mis-assignment of non-library isolates.

197 - Contact with beach sand among beachgoers and risk of illness
C. D. Heaney, E. Sams, S. Wing, S. Marshall, K. Brenner, A.P. Dufour, and T.J. Wade
http://aje.oxfordjournals.org/content/170/2/164.full.pdf
Purpose - The purpose of this study is to better understand the illness risk associated with beach sand that can harbor high concentrations of fecal indicator organisms, as well as fecal pathogens.

Results - The results of our study suggest that, among beachgoers participating in a large prospective cohort study at beaches nearby sewage treatment discharges, reported contact with beach sand (defined as either digging in the sand or having one's body buried in the sand) was associated with an elevated risk of enteric illnesses (gastrointestinal illness and diarrhea). Being buried in the sand was more strongly associated with enteric illness than was digging in the sand. We also observed a higher proportion of people who got sand in their mouth among those buried in the sand (40%) compared with those who dug in the sand (20%).

155 - The Impact of Rainfall on Fecal Coliform Bacteria in Bayou Dorcheat (North Louisiana)
Dagne D. Hill, W.E. Owens, and P.B. Tchounwou
www.mdpi.com/1660-4601/3/1/114/pdf
Purpose - Assess the effect of surface runoff amounts and rainfall amount parameters on fecal coliform bacterial densities in Bayou Dorcheat in Louisiana.

Results - Nonpoint source pollution that is carried by surface runoff has a significant effect on bacterial levels in water resources.

199 - Beach sand and sediments are temporal sinks and sources of Escherichia coli in Lake Superior
Satoshi Ishii, D.L. Hansen, R.E. Hicks, and M.J. Sadowsky
http://pubs.acs.org/doi/pdf/10.1021/es0623156
Purpose - Report on a 2-year investigation of the seasonal variation of E. coli concentrations in water, sand, and sediment at the DBC Beach in the Duluth-Superior Harbor of Lake Superior.

Results - Waterfowl in addition to humans can be a significant source of fecal indicator bacteria like E. coli at Great Lakes beaches. Although waterfowl have been reported to carry a limited number of pathogenic E. coli (36), which was also found our study, they may harbor other potential pathogens such as Salmonella and Campylobacter (37). The potential health risks associated with waterfowl-borne bacteria found at beaches needs to be investigated in the future.

122 - Fecal bacteria and sex hormones in soil and runoff from cropped watersheds amended with poultry litter

Michael B. Jenkins, D.M. Endale, H.H. Schomberg, and R.R. Sharpe

http://phoenix.nal.usda.gov/bitstream/10113/15527/1/IND44044786.pdf

Purpose - Determine if applications of poultry litter to small watersheds would contribute to the load of fecal bacteria and sex hormones to soil and runoff

Results - Under the conditions of drought and conservation tillage, the rates at which we applied poultry litter to the four cropped watersheds appeared to have little or no significant effect on (a) soil community of fecal indicator bacteria, (b) concentrations of estradiol and testosterone in surface soil, and (c) quantities of estradiol and testosterone coming off the watersheds with runoff.

202 - Bacteroidales Diversity in Ring-Billed Gulls (*Laurus delawarensis*) Residing at Lake Michigan Beaches

S.N. Jeter, C.M. McDermott, P.A. Bower, J.L. Kinzelman, M. J. Bootsma, G.W. Goetz, and S.L. McLellan

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2655448/pdf/2261-08.pdf

Purpose - This study investigated the occurrence and diversity of Bacteroidales fecal bacteria in gulls residing in the Great Lakes region.

Results - A total of 467 gull fecal samples from five coastal beaches spanning Lake Michigan's western shore and one inland beach on Lake Winnebago were screened for the presence of Bacteroidales by PCR. There was a low but consistent occurrence of Bacteroidales in the gull populations at these beaches.

151 - The Impact of Annual Average Daily Traffic on Highway Runoff Pollutant Concentrations

Masoud Kayhanian, A. Singh, C. Suverkropp, and S. Borroum

http://escholarship.org/uc/item/86f8c8n8

Purpose - Evaluate correlations between annual average daily traffic and storm water runoff pollutant concentrations generated from California Department of Transportation highway sites.

Results - No direct linear correlation was found between highway runoff pollutant mean concentrations and AADT. However, through multiple regression analyses, it was shown that AADT has an influence on most highway runoff constituent concentrations, in conjunction with factors associated with watershed characteristics and pollutant build-up and wash off.

102 - Development of Bacteroides 16S rRNA Gene TaqMan-Based Real-Time PCR Assays for Estimation of Total, Human, and Bovine Fecal Pollution in Water

Alice Layton, Larry McKay, Dan Williams, Victoria Garrett, Randall Gentry, and Gary Sayler

http://aem.asm.org/content/72/6/4214.full.pdf+html

Purpose - Design real-time PC assay to target Bacteroides species (AllBac) present in human, cattle, and equine feces.

Results - This assay was shown empirically to be proportional to the concentration of human, bovine, and equine feces in water and thus can be used to estimate fecal concentrations without calculating the number of Bacteroides cells in the sample. The simplicity of performing these assays by direct PCR of water samples suggests that these assays may be field deployable and thus would aid data collection in watersheds with inherently high spatial and temporal variabilities.

203 - Persistence of fecal indicator bacteria in Santa Monica Bay beach sediments
C.M. Lee, T.Y. Lin, C.C. Lin, G.A. Kohbodi, A. Bhatt, R. Lee, and J.A. Jay
http://www.sciencedirect.com/science/article/pii/S004313540600220X
Purpose - This study involved monitoring the fecal indicator bacteria (FIB) levels in water and sediment at three ocean beaches (two exposed and one enclosed) during a storm event, conducting laboratory microcosm experiments with sediment from these beaches, and surveying sediment FIB levels at 13 beaches (some exposed and some enclosed).

Results - Results from microcosm experiments showing similar, dramatic growth of FIB in both overlying water and sediment from all beaches, as well as results from the beach survey, support the hypothesis that the quiescent environment rather than sediment characteristics can explain the elevated sediment FIB levels observed at enclosed beaches. This work has implications for the predictive value of FIB measurements, and points to the importance of the sediment reservoir.

205 - Phylogenetic Diversity and Molecular Detection of Bacteria in Gull Feces
J. Lu, J.W. Santo Domingo, R. Lamendella, T. Edge, and S. Hill
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2446513/
Purpose - To determine the occurrence of *C. marimammalium* in waterfowl, species-specific 16S rRNA gene PCR and real-time assays were developed and used to test fecal DNA extracts from different bird (n = 13) and mammal (n = 26) species.

Results - To determine the occurrence of *C. marimammalium* in waterfowl, species-specific 16S rRNA gene PCR and real-time assays were developed and used to test fecal DNA extracts from different bird (n = 13) and mammal (n = 26) species.

103 - Genetic Diversity of Escherichia coli Isolated from Urban Rivers and Beach Water
Sandra L. McLellan
http://aem.asm.org/content/70/8/4658.full.pdf+html
Purpose - Evaluate the genetic profiles of E. coli strains found in stormwater, where fecal pollution is derived from multiple uncharacterized host sources, and compare these profiles to known host sources of pollution.

Results - There does not appear to be a proportional relationship between fecal indicator bacteria from a host and what is actually detected in the environment, which will be an important consideration when developing methods for fecal pollution source tracking. Matching of isolates to the entire data set demonstrated that strains from a type of sample (e.g., gull, sewage, stormwater, river water, beach water) were most similar to other strains from the same host or environmental source. These findings may be a function of geographic distribution rather than host source specificity.

126 - Identification and Quantification of Bacterial Pollution At Milwaukee County Beaches

Sandra L. McLellan, and E.T. Jensen

http://www.glwi.freshwater.uwm.edu/research/genomics/ecoli/media/Technical%20document%209-12-05.pdf

Purpose - Assess the bacterial contaminant load in the waters and sand at beaches within Milwaukee County.

Results - Bacterial water data collected during the summer 2005 beach surveys suggests a positive relationship between rainfall and increased E. coli levels at these particular beach sites. Sewage contamination could potentially reach the beach during combined sewage overflows, or from nearby sewer infrastructure failures.

104 - Evaluation of Repetitive Extragenic Palindromic-PCR for Discrimination of Fecal Escherichia coli from Humans, and Different Domestic and Wild Animals

Bidyut Mohapatra, Klaas Broersma, Rick Nordin and Asit Mazumder

http://web.uvic.ca/~h2o/publications/Mohapatra%20et%20al.%20MI07pdf.pdf

Purpose - Investigate the potential of rep-PCR in differentiating e. coli isolates of human, domestic and wild animal origin that might be used as a molecular tool to identify the possible source(s) of fecal pollution of source water.

Results - Rep-PCR DNA fingerprinting results provide evidence about the robustness of this method, and it's simple and cost-effective screening tool to isolate and track non-point sources of fecal contamination.

106 - Evaluation of antibiotic resistance analysis and ribotyping for identification of faecal pollution sources in an urban watershed

D.F. Moore, V.J. Harwood, D.M. Ferguson, J. Lukasik, P. Hannah1, M. Getrich and M. Brownell

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2005.02612.x/pdf

Purpose **-** The accuracy of ribotyping and antibiotic resistance analysis (ARA) for prediction of sources of faecal bacterial pollution in an urban Southern California watershed was determined using blinded proficiency samples. Low rates of correct classification for E. coli proficiency isolates compared with the ARCCs of the libraries indicate that testing of bacteria from samples that are not represented in the library, such as blinded proficiency samples, is necessary to accurately measure predictive ability. The library-based MST methods used in this study may not be suited for determination of the source(s) of faecal pollution in large, urban watersheds.

Results - None of the methods performed well enough on the proficiency panel to be judged ready for application to environmental samples.

210 - Species distribution and antimicrobial resistance of enterococci isolated from surface and ocean water
D.F. Moore, J.A. Guzman, and C. McGee
http://www.glin.net/lists/beachnet/2008-05/pdf00000.pdf
Purpose - The species identification and antimicrobial resistance profiles were determined for enterococci isolated from Southern California surface and ocean waters.

Results - *Enterococcus faecalis, E. faecium, E. casseliflavus and E. mundti* are the most commonly isolated Enterococcus species from urban runoff and receiving waters in Southern California.

107 - A review of technologies for rapid detection of bacteria in recreational waters
Rachel T. Noble and Stephen B. Weisberg
http://www.environmental-expert.com/Files%5C19961%5Carticles%5C6674%5C479_rapid_detection_recreational_waters.pdf
Purpose - Review new methods that have the potential to reduce measurement period for fecal indicator bacteria from more than a day to less than an hour to reduce risk of swimmers to fecal bacteria.

Results - Enzyme substrate methods are most likely to be the first rapid methods adopted for recreational water quality. Enzymatic substrate methods are based on the same capture technology as currently-approved EPA methods, with greater speed attained through enhanced detection technology. As such, the relationship to health risk can be established by demonstrating that the new detection capability produces equivalent results to existing procedures.

214 - Comparison of total coliform, fecal coliform, and enterococcus bacterial indicator response for ocean recreational water quality testing
Rachel T. Noble, D.F. Moore M.K. Leecaster, C.D. McGee, and S.B. Weisberg
http://www.ochealthinfo.com/docs/public/epi/h2o/Water-Research-Publication-2003.pdf
Purpose - To compare the relationship between the bacterial indicators, and the effect that changing the standards would have on recreational water regulatory actions, three regional studies were conducted along the southern California shoreline from Santa Barbara to San Diego, California.

Results - Cumulatively, our results suggest that replacement of a TC standard with an EC standard will lead to a five-fold increase in failures during dry weather and a doubling of failures during wet weather. Replacing a TC standard with one based on all three indicators will lead to an eight-fold increase in failures. Changes in the requirements for water quality testing have strong implications for increases in beach closures and restrictions.

217 - Relationships between sand and water quality at recreational beaches

M.C. Phillips, H.M. Solo-Gabriele, A.M. Piggot, J.S. Klaus and Y. Zhang

http://www.sciencedirect.com/science/article/pii/S0043135411006269

Purpose - Enterococci are used to assess the risk of negative human health impacts from recreational waters. Studies have shown sustained populations of enterococci within sediments of beaches but comprehensive surveys of multiple tidal zones on beaches in a regional area and their relationship to beach management decisions are limited.

Results - We sampled three tidal zones on eight South Florida beaches in Miami-Dade and Broward counties and found that enterococci were ubiquitous within South Florida beach sands although their levels varied greatly both among the beaches and between the supratidal, intertidal and subtidal zones.

218 - Shedding of Staphylococcus aureus and methicillin-resistant Staphylococcus aureus from adult and pediatric bathers in marine waters

L.R.W. Plano, A.C. Garza, T. Shibata, S.M. Elmier, J. Kish, C.D. Sinigalliano,M.L. Gidley, G. Miller, K. Withum, L.E. Fleming, and H.M. Solo-Gabriele

http://www.biomedsearch.com/attachments/00/21/21/10/21211014/1471-2180-11-5.pdf

Purpose - The primary aim of this study was to evaluate the amount and characteristics of the shedding of methicillin sensitive S. aureus, MSSA and MRSA by human bathers in marine waters.

Results - Twelve of 15 MRSA isolates collected from the water had identical genetic characteristics as the organisms isolated from the participants exposed to that water while the remaining 3 MRSA were without matching nasal isolates from participants. The amount of S. aureus shed per person corresponded to 105 to 106 CFU per person per 15-minute bathing period, with 15 to 20% of this quantity testing positive for MRSA. These findings clearly demonstrate that adults and toddlers shed their colonizing organisms into marine waters and therefore can be sources of potentially pathogenic S. aureus and MRSA in recreational marine waters. Additional research is needed to evaluate recreational beaches and marine waters as potential exposure and transmission pathways for MRSA.

111 - A comparison of ARA and DNA data for microbial source tracking based on source-classification models developed using classification trees

Bertram Price, Elichia Venso, Mark Frana, Joshua Greenberg, and Adam Ware

http://faculty.salisbury.edu/~mffrana/Cell%20Biol%20Spring%2008/Frana%20paper,%20after.pdf

Purpose - Determine whether increased reliability, if any, of library-based MST developed with DNA data is sufficient to justify its higher cost, where source predictions are used in TMDL surface water management programs.

Results - While the overall rates of correct classification are higher for the DNA data than for the ARA data, the resulting source predictions for both data indicate similar TMDL surface water bacterial contamination reduction strategies. Questioning the value of DNA data relative to ARA data for MST intended for application in a TMDL program is justified, and the answer may favor ARA data for this application.

112 - Quantitative PCR Method for Sensitive Detection of Ruminant Fecal Pollution in Freshwater and Evaluation of This Method in Alpine Karstic Regions
Georg H. Reischer, David C. Kasper, Ralf Steinborn, Robert L. Mach, and Andreas H. Farnleitner
http://aem.asm.org/content/72/8/5610.full.pdf+html
Purpose - Establish a method for the sensitive quantification of ruminant fecal pollution in spring water and groundwater from alpine karstic regions important for public water supplies. Identify a ruminant-specific genetic marker in fecal members of the phylum Bacteroidetes.

Results - The marker could be found at concentrations ranging from not detectable in 4.5 liters (KPAS) to 106 marker equivalents per liter (LKAS2 flood). Strong differences in occurrence were obvious and in accordance with the expected different levels of ruminant fecal.

Preliminary experiments testing the stability of the marker in highly diluted fecal suspensions in spring water at ambient temperatures (4°C) found no strong reduction of detectable marker levels during an incubation period of 2 months.

After additional evaluation, the assay might allow the specific allocation of fecal pollution in alpine water sources, enabling target oriented measures in the catchment area and thus facilitating watershed management. Furthermore, it could also provide additional information for quantitative microbial risk assessment studies as part of water safety plans recommended by the WHO (35), allowing the relative estimation of ruminant fecal input compared to other sources.

164 - Pathogenic fungi: an unacknowledged risk at coastal resorts? New insights on microbiological sand quality in Portugal
R. Sabino, C. Verissimo, M.A. Cunha, B. Wergikoski, F.C. Ferreira, R. Rodrigues, H. Parada, L. Falcão, L. Rosado, C. Pinheiro, E. Paixão, and J. Brandão
http://www.sciencedirect.com/science/article/pii/S0025326X11001962
Purpose - Determine the presence of yeasts, pathogenic fungi, dermatophytes, total coliforms, Escherichia coli and intestinal enterococci in sand at thirty-three beaches across Portugal.

Results - Results showed that 60.4% of the samples were positive for fungi and that 25.2% were positive for the bacterial parameters. The most frequent fungal species found were Candida sp. and Aspergillus sp., whereas intestinal enterococci were the most frequently isolated bacteria.

Positive associations were detected among analyzed parameters and country-regions but none among those parameters and sampling period. Regarding threshold values, we propose 15 cfu/g for yeasts, 17 cfu/g for potential pathogenic fungi, 8 cfu/g for dermatophytes. Eighty four cfu/g for coliforms, 250 cfu/g for E. coli, and 100 cfu/g for intestinal enterococci.

114 - The use of ribotyping and antibiotic resistance patterns for identification of host sources of Escherichia coli strains

M. Samadpour, M.C. Roberts, C. Kitts, W. Mulugeta and D. Alfi

http://onlinelibrary.wiley.com/doi/10.1111/j.1472-765X.2004.01630.x/pdf

Purpose - To compare antibiotic resistance and ribotyping patterns ability to identify triplicate isolates sent from a group of 40 Escherichia coli taken from seven host sources.

Results - Of the 120 isolates, 22 isolates were resistant to ampicillin, streptomycin, tetracycline and trimethoprim and 98 isolates were susceptible. Antibiotic patterns identified 33 of the triplicates and three of the six groups had isolates from multiple hosts. Ribotyping divided the isolates into 27 ribotype groups with all triplicates grouped into the same ribotype group with one host per group.

219 - The effects of rainfall on Escherichia coli and total coliform levels at 15 Lake Superior recreational beaches

R. Sampson, S. Swiatnicki, C. McDermott, and G. Kleinheinz

http://www.environmental-expert.com/Files%5C6063%5Carticles%5C9235%5C11-12-6.pdf

Purpose - Fifteen beaches along Lake Superior were monitored over the course of the 2003 and 2004 summer swimming seasons from mid-May through mid-September. Water samples were collected at these 15 beaches less than 24-h after a rainfall event of at least 6 mm. The effect of rainfall on bacterial concentrations along the Wisconsin shores of Lake Superior was investigated.

Results - No relationship between rainfall amount and bacterial concentrations at any of the 15 beaches tested was found. Although other researchers have observed a direct positive relationship between rainfall and E. coli levels in beach water, we found no significant relationship for Lake Superior beaches. This is an important finding given the fact that beach closures are often based upon rainfall alone rather than on actual E. coli concentration measurements. This study reinforces the fact that the data obtained at one location should not necessarily be extrapolated to beach closure decisions at other locations.

141 - Modeling the dry-weather tidal cycling of fecal indicator bacteria in surface waters of an intertidal wetland

Brett F. Sanders, F. Arega, and M. Sutula

ftp://www.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2005_06AnnualReport/AR0506_051-66.pdf

Purpose - Utilize a developed model and apply it to predict the dry-weather tidal cycling of FIB in Talbert Marsh, in response to loads from urban runoff, bird feces and resuspended sediments.

Results - Model predictions show that surface water concentrations of TC, EC, and ENT in the wetland are driven by loads from urban runoff and resuspended wetland sediments. The model more accurately predicts TC than EC or ENT. The crucial role that sediments play in the cycling of FIB is highlighted by this study. Sediments function as a reservoir of FIB that may accumulate FIB due to regrowth or settling, or shed FIB when tidal currents or storm flows scour away or even just disturb surficial particles.

115 - Patterns of Antimicrobial Resistance Observed in Escherichia coli Isolates Obtained from Domestic- and Wild-Animal Fecal Samples, Human Septage, and Surface Water
Raida S. Sayah, J.B. Kaneene, Y. Johnson, and R. Miller
http://aem.asm.org/content/71/3/1394.full.pdf+html
Purpose - (i) To identify patterns of antimicrobial agent resistance of E. coli strains obtained from human septage, domestic animals, and wildlife living in the Red Cedar watershed in Michigan, and (ii) to compare these antimicrobial agent resistance patterns with those of E. coli strains obtained from surface water in the same watershed.

Results - Antimicrobial agent resistance was detected in all types of samples collected (Table 4). The most frequently encountered form of resistance in all samples was resistance to tetracycline (27.3%), followed by resistance to cephalothin (22.7%), resistance to sulfisoxazole (13.3%), and resistance to streptomycin (13.1%). Animal fecal samples exhibited resistance to all agents tested, while human septage and river water samples showed resistance to three agents and one agent, respectively.
Resistance to cephalothin was present in all types of samples, while tetracycline resistance and streptomycin resistance were found in all types of samples except river water. Resistance to tetracycline was present in both fecal and farm environment samples from all livestock species, while resistance to trimethoprim-sulfamethoxazole was present in both types of samples from only dairy cattle and equids.

142 - Tracking sources of bacterial contamination in stormwater discharges from Mission Bay, California
Kenneth C. Schiff, and P. Kinney
ftp://www.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/1999AnnualReport/07_ar06.pdf
Purpose - Identify whether wet-weather discharges were the predominant source of bacterial contamination to receiving waters.

Results - Seasonal cycles were evident, with the highest levels of total coliform, fecal coliform and enterococcus occurring during the wettest months.

220 - Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather. Technical Report #448
Kenneth C. Schiff, J. Griffith, and G. Lyon

http://www.sccwrp.org:8060/pub/download/DOCUMENTS/TechnicalReports/448_reference_beach.pdf
Purpose - Assess the microbial water quality at reference beaches following wet weather events in southern California.

Results - Based on the results from this study, natural contributions of nonhuman fecal indicator bacteria were sufficient to generate exceedances of the State of California water quality thresholds during wet weather.

145 - Water Quality Indicators and the Risk of Illness in Non-Point Source Impacted Recreational Waters
Kenneth C. Schiff, S.B. Weisberg and J.M. Colford Jr.
ftp://swrcb2a.waterboards.ca.gov/pub/rwqcb2/TMDL-WEF/5d.pdf
Purpose - Determine if: 1) water contact increased the risk of illness in the two weeks following exposure to water in Mission Bay? and 2) did the risk of illness increase with increasing levels of microbial indicators of water quality?

Results - Outside of skin rash and diarrhea, there was no statistically increased risk of 12 other symptoms, including highly credible gastrointestinal illness (HCGI). These results contrast with most other recreational bathing studies, most likely because of the lack of human sources of fecal pollution.

165 - Variation of microorganism concentrations in urban stormwater runoff with land use and seasons
A. Selvakumar, and M. Borst
http://www.iwaponline.com/jwh/004/0109/0040109.pdf
Purpose - This study investigates if variations in concentrations of microorganisms by at least 1/3-log at the 95% level of confidence are potentially attributable to land use and seasons. Differences less than 1/3-log have little practical importance even if there is statistical significance as the sensitivity of the analyses procedure is less than these.

Results - Statistically significant differences were found between land uses for all microorganisms studied except for E. coli. Other than E. coli, the microbial concentrations in stormwater runoff consistently vary within and between land uses. Generally, the concentrations in runoff from high-density residential areas are higher than the concentrations in other tested land uses.

222 - Indicator microbes correlate with pathogenic bacteria, yeasts and helminthes in sand at a subtropical recreational beach site
A.H. Shah, A.M. Abdelzaher, M. Phillips, R. Hernandez, H.M. Solo-Gabriele, J. Kish, G. Scorzetti, J.W. Fell, M.R. Diaz, T.M. Scott, J. Lukasik, V.J. Harwood,, S. McQuaig, C.D. Sinigalliano, M.L. Gidley, D. Wanless, A. Ager, J. Lui, J.R. Stewart, L.R. Plano, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pubmed/21447014

Purpose - The objectives of this study were to evaluate the presence and distribution of pathogens in various zones of beach sand (subtidal, intertidal and supratidal) and to assess their relationship with environmental parameters and indicator microbes at a non-point source subtropical marine beach.

Results - Results indicate that indicator microbes may predict the presence of some of the pathogens, in particular helminthes, yeasts and the bacterial pathogen Staphylococcus aureus including methicillin-resistant forms. Indicator microbes may thus be useful for monitoring beach sand and water quality at non-point source beaches.

132 - Evaluation of conventional and alternative monitoring methods for a recreational marine beach with non-point source of fecal contamination

Tomoyuki Shibata, H.M. Solo-Gabriele, C.D. Sinigalliano, M.L. Gidley, L.R.W. Plano, J.M. Fleisher, J.D. Wang, S.M. Elmir, G. He, M.E. Wright, A.M. Abdelzaher, C. Ortega, D. Wanless, A.C. Garza, J. Kish, T. Scott, J. Hollenbeck, L.C. Backer, and L.E. Fleming

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2966524/

Purpose - Compare enterococci (ENT) measurements based on the membrane filter, ENT(MF) with alternatives that can provide faster results including alternative enterococci methods (e.g. chromogenic substrate (CS), and quantitative polymerase chain reaction (qPCR)), and results from regression models based upon environmental parameters that can be measured in real-time.

Results - In addition to physico-chemical and hydrometeorological parameters, results also suggested that bacterial indicator levels were affected by the numbers of animals on the beach which may also have seasonal patterns associated with their numbers and fecal inputs. Thus, levels of enterococci at non-point source beaches are affected by a myriad of environmental factors and input loadings which are very difficult to capture within simple regression models.

223 - Adhesion of Enterococcus faecalis in the nonculturable state to plankton is the main mechanisms responsible for persistence of this bacterium in both lake and seawater

C. Signoretto, G. Burlacchini, M. del Mar Lleò, C. Pruzzo, M. Zampini, L. Pane, G. Franzini, and P. Canepari

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC525140/

Purpose - In this study we describe the results of the monitoring of the microbiological quality of both freshwater and marine water by applying an approach consisting of detecting both culturable and nonculturable enterococci which are present in water and adherent to the plankton in order to evaluate to what extent the adhesion to plankton and the VBNC state may represent survival strategies and contribute to the formation of environmental reservoirs of these microorganisms.

Results - We show that molecular methods for the detection of enterococci resulted in a higher number of positive samples than the culture method. The most interesting result of this study was the observation that in Lake Garda E. faecalis is almost exclusively found either adhering to plankton or in water, and not both. This result was also confirmed by the results in seawater, although not to such an evident extent.

123 - TRANSPORT OF FECAL BACTERIA FROM POULTRY LITTER AND CATTLE MANURES APPLIED TO PASTURELAND

M.L. Soupir, S. Mostaghimi, E.R. Yagow, C. Hagedorn, and D.H. Vaughan

http://www.environmental-center.com/Files%5C0%5Carticles%5C9338%5CTransportOfFecalBacteria.pdf

Purpose - An understanding of the overland transport mechanisms from land applied waste is needed to improve design of best management practices (BMPs) and modeling of nonpoint source (NPS) pollution.

Results - Results of this comparative study clearly indicate that cowpies have a greater potential to contribute high fecal bacteria concentrations into streams than the land application of liquid dairy manure or turkey litter, although bacteria concentrations in runoff from all treatments exceeded Federal standards for primary contact in the United States. The relationship between runoff rates and concentrations of the indicator species was dependent upon the animal waste application, the indicator species and antecedent soil moisture conditions.

152 - Variability of Indicator Bacteria at Different Time Scales in the Upper Hoosic River Watershed

Elena Traister, and S.C. Anisfeld

http://www.forestry.yale.edu/uploads/publications/Anisfeld-pub03.pdf

Purpose - Evaluate whether the Upper Hoosic River Basin is meeting water quality criteria for indicator bacteria.

Results - Bacterial levels were higher in more developed watersheds; in summer rather than winter; in storms rather than baseflow; and in the early morning rather than afternoon.

227- Prevalence of yeasts in beach sand at three bathing beaches in South Florida

C. Vogel, A. Rogerson, S. Schatz, H. Laubach, A. Tallman, and J. Fell

http://www.sciencedirect.com/science/article/pii/S004313540700108X

Purpose - Determine the abundance and types of yeasts in the wet and dry sand of three recreational beaches in South Florida.

Results - While definitive statements cannot be made, high levels of yeasts may have a deleterious bearing on human health and the presence of such a diverse aggregation of species suggests that yeasts could have a role as indicators of beach health.

224 - Effect of waterfowl (Anas platyrhynchos) on indicator bacteria populations in a recreational lake in Madison, Wisconsin

J.H. Standridge, J.J. Delfino, L.B. Kleppe, and R. Butler

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC243530/pdf/aem00202-0205.pdf

Purpose - Determine the level of effect that waterfowl has on the water quality of a Madison, WI lake.

Results - The most common human health hazard associated with ducks is swimmer's itch, or echinostoma revolutum (12). The duck tapeworm can also occasionally infect humans (4). Ducks have often been implicated as carriers and disseminators of Salmonella (1, 3, 11, 12, 16, 17). The occurrence of these zoonoses indicates that fecal contamination from ducks is a human health hazard and that beach closings based on the presence of high counts of fecal coliform indicator bacteria are warranted. Future surveys aimed at detecting the possible presence of Salmonella in the Vilas Park beach area are indicated.

228 - Estimation of enterococci input from bathers and animals on a recreational beach using camera images
J.D. Wang, H.M. Solo-Gabriele, Am. M. Abdelzher, and L.E. Fleming
http://www.sciencedirect.com/science/article/pii/S0025326X10001062
Purpose - Develop a counting methodology to better understand non-point source load impacts. Enterococci inputs to the study beach site (located in Miami, FL) are dominated by non-point sources (including humans and animals).

Results - Enterococci source functions were computed from the observed number of unique individuals for average days of each month of the year, and from average load contributions for humans and for animals. Results indicate that dogs represent the larger source of enterococci relative to humans and birds.

229 - Hand-mouth transfer and potential for exposure to E. coli and F+ coliphage in beach sand, Chicago, Illinois
R.L. Whitman, K. Przybyla-Kelly, D.A. Shively, M.B. Nevers, and M.N. Byappanahalli
http://www.ncbi.nlm.nih.gov/pubmed/19590129
Purpose - Examine the transferability of Escherichia coli and F+ coliphage (MS2) from beach sand to hands in order to estimate the potential subsequent health risk.

Results - Using dose-response estimates developed for swimming water, it was determined that the number of individuals per thousand that would develop gastrointestinal symptoms would be 11 if all E. coli on the fingertip were ingested or 33 if all E. coli on the hand were ingested. These results suggest that beach sand may be an important medium for microbial exposure; bacteria transfer is related to initial concentration in the sand; and rinsing may be effective in limiting oral exposure to sand-borne microbes of human concern.

169 - Microbial load from animal feces at a recreational beach
M.E. Wright, H.M. Solo-Gabriele, S. Elmir, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/pdf/nihms138348.pdf
Purpose - The goal of this study was to quantify the microbial load (enterococci) contributed by the different animals that frequent a beach site.

Results - The highest enterococci concentrations were observed in dog feces with average levels of 3.9 x 10(7) CFU/g; the next highest enterococci levels were observed in birds averaging 3.3 x 10(5)CFU/g. The lowest measured levels of enterococci were observed in material collected from shrimp fecal mounds (2.0 CFU/g). A comparison of the microbial loads showed that 1 dog fecal event was equivalent to 6940 bird fecal events or 3.2 x 10(8) shrimp fecal mounds. Comparing animal contributions to previously published numbers for human bather shedding indicates that one adult human swimmer contributes approximately the same microbial load as one bird fecal event. Given the abundance of animals observed on the beach, this study suggests that dogs are the largest contributing animal source of enterococci to the beach site.

231 - Microbial load from animal feces at a recreational beach
M.E. Wright, H.M. Solo-Gabriele, S. Elmir, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/
Purpose - Quantify the microbial load (enterococci) contributed by the different animals that frequent a beach site.

Results - Results from this study provide evidence that dog feces represent the largest animal source to the study site. Improved management of dog feces at the beach could potentially reduce enterococci inputs to the beach, thereby decreasing the number of advisories for beach sites which are frequented by significant numbers of dogs.

8 - Are microbial indicators and pathogens correlated? A statistical analysis of 40 years of research
J. Wu, S. C. Long, D. Das and S. M. Dorner
http://www.iwaponline.com/jwh/up/wh2011117.htm
Purpose - The data were analyzed to assess factors affecting correlations using a logistic regression model considering indicator classes, pathogen classes, water types, pathogen sources, sample size, the number of samples with pathogens, the detection method, year of publication and statistical methods.

136 - Monitoring and Modeling Non-Point Source Contributions of Host-Specific Fecal Contamination in San Pablo Bay
Stefan Wuertz, F.A. Bombardelli, K. Sirikanchana, and D. Wang
http://escholarship.org/uc/item/8tk0z6p0.pdf
Purpose - This study employed mathematical and numerical transport models in concert with new molecular techniques to (i) characterize the sources of fecal contamination of water bodies and (ii) quantify the loads and distributions of *Bacteroidales* marker DNA sequences originating from different animal hosts in San Pablo Bay.

Results - Microbial source tracking using fecal *Bacteroidales* is an effective way to monitor fecal pollution of coastal waters. Low levels of the universal genetic marker are ubiquitous throughout

San Pablo Bay. The human marker BacHum-UCD was found in 75% of all samples but no cow- and almost no dog-specific marker was detected.

234 - Growth of enterococci in unaltered, unseeded beach sands subjected to tidal wetting
K.M. Yamahara, S.P. Walters, and A.B. Boehm
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2655449/
Purpose - To establish if naturally occurring enterococci can replicate in beach sands under environmentally relevant conditions.

Results - The results provide evidence that enterococci may not be an appropriate indicator of enteric disease risk at recreational beaches subject to nonpoint sources of pollution.

170 - A water quality modeling study of non-point sources at recreational marine beaches
X. Zhu, J.D. Wang, H.M. Solo-Gabriele, L.E. Fleming
http://www.sciencedirect.com/science/article/pii/S0043135411001266
Purpose - A model study was conducted to understand the influence of non-point sources including bather shedding, animal fecal sources, and near shore sand, as well as the impact of the environmental conditions, on the fate and transport of the indicator microbe, enterococci, at a subtropical recreational marine beach in South Florida.

Results - Enterococci released from beach sand during high tide caused mildly elevated concentration for a short period of time (ten to twenty of CFU/100 ml initially, reduced to 2 CFU/100 ml within 4 h during sunny weather) similar to the average baseline numbers observed at the beach. Bather shedding resulted in minimal impacts (less than 1 CFU/100 ml), even during crowded holiday weekends. In addition, weak current velocity near the beach shoreline was found to cause longer dwelling times for the elevated concentrations of enterococci, while solar deactivation was found to be a strong factor in reducing these microbial concentrations.

APPENDIX H

Identification of Goals

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APPENDIX H. IDENTIFICATION OF GOALS

Numeric goals have been developed to support Water Quality Improvement Plan implementation and are used to measure progress toward addressing the highest priority water quality conditions. Numeric goals may take a variety of forms, but are quantifiable so that progress toward and achievement of the goals are measurable. Applicable Total Maximum Daily Load (TMDL) targets are required to be incorporated as Water Quality Improvement Plan goals. Also in accordance with the MS4 Permit and applicable regulatory drivers, final goals and reasonable interim goals for each five-year period from Water Quality Improvement Plan approval to the anticipated final goal compliance date (including an interim goal for this permit term) have been developed. This appendix presents Bacteria TMDL numeric targets, how the targets were derived, and how the targets were translated into Water Quality Improvement Plan numeric goals.

Within the San Dieguito River WMA, the Bacteria TMDL dictates the bacteria goals for each weather condition to address and attain Recreational Water Contact (REC-1) beneficial uses. A TMDL represents the maximum amount of a pollutant of concern that a water body can receive and still attain water quality standards. TMDLs can take a variety of forms, including concentration-based TMDLs, which focus on reducing pollutant sources to achieve a maximum pollutant concentration consistent with existing water quality objectives (WQOs), and load-based TMDLs, which focus on reducing sources to achieve a watershed-specific maximum load that is protective of beneficial uses. The Bacteria TMDL incorporates load-based reductions that were calculated on the basis of watershed modeling results and applicable bacteria WQOs.

Although the Pacific Ocean shoreline segment was removed from the 303d list for REC-1 impairment in 2010, calculation of the Bacteria TMDL had already begun and the segment remained in the TMDL through adoption in 2011. The San Dieguito shoreline segment was then incorporated into the Bacteria TMDL requirements within the MS4 Permit in 2013. Therefore, the TMDL targets are required to be incorporated into the Water Quality Improvement Plan goals. If monitoring data supports compliance with wet and dry weather Bacteria TMDL targets, the Responsible Agencies will use the adaptive management protocol in Section 6 to identify new highest priority water quality conditions and develop goals and strategies to address new priorities.

The final and interim numeric goals for the San Dieguito River WMA were derived from water quality-based effluent limitations (WQBELs) identified in the Bacteria TMDL and incorporated into the MS4 Permit. Bacteria TMDL WQBELs include receiving water limitations and effluent limitations, presented in multiple formats. The receiving water limitations and effluent limitations are discussed in detail in Section H.1 and Section H.2, respectively. Attachment E.4 of the Municipal Permit provides the following options to meet numeric goals and to demonstrate final compliance with the Bacteria TMDL:

(1) There is no direct or indirect discharge from the Responsible Agency's municipal separate storm sewer systems (MS4s) to the receiving water; OR

(2) There are no exceedances of the final receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(3) There are no exceedances of the final effluent limitations at the Responsible Agency's MS4 outfalls; OR

(4) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the final effluent limitations; OR

(5) The Responsible Agencies can demonstrate that exceedances of the final receiving water limitations in the receiving water are due to loads from natural sources, AND pollutant loads from the Responsible Agencies'' MS4 are not causing or contributing to the exceedances; OR

(6) The Responsible Agencies develop and implement the Water Quality Improvement Plan as follows:

   (a) The Responsible Agencies incorporate best management practices (BMPs) to achieve the receiving water limitations and/or the effluent limitations,

   (b) The Responsible Agencies include an analysis in the Water Quality Improvement Plan, utilizing a watershed model or other watershed analytical tools, to demonstrate that the implementation of the BMPs achieves compliance with the final receiving water and/or effluent limitations,

   (c) The results of the analysis must be accepted by the San Diego Water Board as part of the Water Quality Improvement Plan,

   (d) The Responsible Agencies continue to implement the BMPs, and

   (e) The Responsible Agencies continue to perform the specific monitoring and assessment specified to demonstrate compliance with the receiving water and effluent limitations (RWQCB, 2013a).

H.1 Receiving Water Limitations

Bacteria TMDL receiving water limitations are expressed as concentrations and as an allowable exceedance frequency. The limitations vary depending on the weather condition. The Bacteria TMDL identified WQBELs based on precipitation: wet weather (day of 0.2 inch of rain or more plus three days) and dry weather (all other days, including those in the winter season). For each condition, receiving water targets were identified based on water quality objectives (WQOs) (Table H-1). WQOs are concentrations of bacteria indicators identified as acceptable levels for REC-1. Wet weather conditions are episodic and short in duration; therefore, single-sample maximum WQOs apply. Geometric mean WQOs apply during dry weather when monitoring results over a longer duration are averaged and assessed. The WQOs do not account for a natural increase in bacteria at the shoreline during storm events. To account for background bacteria concentrations during wet weather, the Bacteria TMDL incorporated an allowable exceedance frequency of the WQO based on a reference (mostly undeveloped) watershed.

Table H-1
Final Receiving Water Numeric Goals for San Dieguito River WMA

Indicator Bacteria	Shoreline WQO (MPN/100mL)	Shoreline Allowable Exceedance Frequency[1]	Shoreline WQO (MPN/100mL)	Shoreline Allowable Exceedance Frequency
	Wet Weather (Single Sample Maximum)[2]		Dry Weather (30-day Geometric Mean)[3]	
	Final Compliance: April 4, 2031		Final Compliance: April 4, 2021	
Fecal coliform	400	22%	200	0%
Enterococcus	104	22%	35	0%
Total Coliform	10,000	22%	1,000	0%

Note:
1. The 22% allowable exceedance frequency only applies to wet weather days. For dry weather days, the dry weather bacteria densities must be consistent with the single sample maximum REC-1 water quality objects in the Ocean Plan.
2. During wet weather days, only the single sample maximum receiving water limitations are required to be achieved.
3. During dry weather days, the single sample maximum and 30-day geometric mean receiving water limitations are required to be achieved.

% = percent; mL = milliliters; MPN = most probable number; WQO = water quality objective

The Bacteria TMDL specifies a final receiving water limitation allowable exceedance frequency of 22 percent during wet weather periods based on reference conditions, but allows no exceedances during dry weather. To assess compliance, the Bacteria TMDL expressed exceedances of WQOs as the number of days that the appropriate WQO would be exceeded. The TMDL calculated this number using a mass-based conversion based on bacteria loading, as required by federal regulations (Bacteria TMDL). The TMDL load was calculated by multiplying the WQOs by the daily modeled stream flow. Modeled daily loads greater than this threshold were flagged as an exceedance. Modeled daily loads were classified as occurring on either wet weather days or dry weather days to determine compliance with the different weather-based requirements. For wet weather, the Bacteria TMDL specifies a final allowable exceedance frequency of 22 percent based on reference conditions, while no exceedances are allowed during dry weather. For wet weather, the daily loads from wet weather days greater than the TMDL and the calculated allowable exceedance loads (load from the 22 percent of the allowable days) were flagged as exceedances. For dry weather days, the daily loads from dry weather days greater than the TMDL were flagged as exceedances.

The number of total wet and dry weather days will change by year, but the percentage of exceedance days is the compliance point. For example, the TMDL calculated the number of allowable exceedance days for the critical, or wettest, year within the model period, water year 1993. The number of wet weather days was 98; therefore, the final number of allowable wet weather exceedance days for the critical year would have been 22 (rounded expression of 22 percent of 98 days). The final allowable number of dry weather exceedance days for the critical year is zero, because a reference condition was not applied to dry weather days in the TMDL. Final compliance with wet weather WQBELs is required in fiscal year (FY) 31. Final compliance with dry weather WQBELs is required in FY21.

H.2 Effluent Limitations

The Bacteria TMDL provides two expressions of effluent limitations. The first expression is equivalent to the receiving water limitations, but is assessed at MS4 outfalls (Table H-2). The second expression is a mass-based load reduction from the subwatersheds discussed below.

Table H-2
Final Effluent Limitations Expressed as an Exceedance Frequency for San Dieguito River WMA

Indicator Bacteria	WQO (MPN/100mL)	MS4 Outfall Allowable Exceedance Frequency[1]	WQO (MPN/100mL)	MS4 Outfall Allowable Exceedance Frequency
	Wet Weather (Single Sample Maximum)[2]		Dry Weather (30-day Geometric Mean)[3]	
	Final Compliance: April 4, 2031		Final Compliance: April 4, 2021	
Fecal coliform	400	22%	200	0%
Enterococcus	104	22%	35	0%
Total Coliform	10,000	22%	1,000	0%

Note:
1. The 22% allowable exceedance frequency only applies to wet weather days. For dry weather days, the dry weather bacteria densities must be consistent with the single sample maximum REC-1 water quality objects in the Ocean Plan.
2. During wet weather days, only the single sample maximum receiving water limitations are required to be achieved.
3. During dry weather days, the single sample maximum and 30-day geometric mean receiving water limitations are required to be achieved.

% = percent; mL = milliliters; MPN = most probable number; WQO = water quality objective

Another expression of WQBELs is the percent bacteria load reduction required from the watershed to meet the WQOs expressed as an allowable exceedance frequency. The Bacteria TMDL calculated the watershed load reductions that were required to achieve the Bacteria TMDL receiving water limitations. The MS4 Permit incorporated these load reductions for wet and dry weather as effluent limitations. The loading capacity was calculated by multiplying the WQOs by the average daily modeled stream flow. Modeled daily loads greater than this threshold were flagged as an exceedance. The allowable exceedance load for wet weather was calculated by summing the top 22 days (22 percent of the 98 wet weather days in the critical year) with the highest modeled daily loads. This load was then subtracted from the modeled wet weather total for the year.

The difference between the remaining modeled load and the TMDL load represents the load reduction required for wet weather. The percent load reduction is calculated by dividing the exceedance load by the total annual load for the critical year. The final load reductions estimated to meet receiving water goals are presented in Table H-3.

Table H-3
Final Effluent Limitations Expressed as an Exceedance Frequency for San Dieguito River WMA

Indicator Bacteria	Percent Watershed Load Reduction Required	
	Wet Weather	Dry Weather
	Final Compliance: April 4, 2031	Final Compliance: April 4, 2021
Fecal coliform	1.5%	20.7%
Enterococcus	7.7%	83.5%
Total coliform	4.3%	14.4%

Dry weather WQBELs, expressed as percent watershed load reduction, were calculated using the same formula, but daily loads were calculated using a slightly different model (steady-state plug-flow reactor model) in the Bacterial TMDL. Two variations in the calculation are that (1) an allowable load using the reference watershed approach was not applied for dry weather, per the TMDL, and (2) the percent load reductions were calculated based on a 30-day period for comparison with the 30-day geometric mean WQO. Otherwise, the TMDL load was calculated in the same manner as that for the wet weather load and the difference between the remaining modeled load and the TMDL load is the load reduction required for dry weather. The percent load reduction is calculated by dividing the exceedance load by the total monthly load for the critical year (Table H-2).

H.3 Interim Goals and Existing Conditions

The first five TMDL interim compliance pathways are the same as the final compliance pathways. In addition, two compliance pathways (6 and 7 below) provide interim compliance calculated using a midpoint between existing conditions and final targets. Finally, compliance pathway 8 provides interim compliance with the TMDL if the Responsible Agencies are implementing strategies selected and included in a watershed model or other analytical tool to demonstrate that the interim TMDL compliance requirements will be met. Attachment E.4 of the Municipal Permit provides the following options to meet interim numeric goals and to demonstrate interim compliance with the Bacteria TMDL:

(1) There is no direct or indirect discharge from the Responsible Agency's municipal separate storm sewer systems (MS4s) to the receiving water; OR

(2) There are no exceedances of the final receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(3) There are no exceedances of the final effluent limitations at the Responsible Agency's MS4 outfalls; OR

(4) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the final effluent limitations; OR

(5) The Responsible Agencies can demonstrate that exceedances of the final receiving water limitations in the receiving water are due to loads from natural sources, AND pollutant loads from the Responsible Agencies'' MS4 are not causing or contributing to the exceedances; OR

(6) There are no exceedances of the interim receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(7) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the interim effluent limitations; OR

(8) The Responsible Agencies submit and are fully implementing a Water Quality Improvement Plan, accepted by the San Diego Water Board, which provides reasonable assurance that the interim TMDL compliance requirements will be achieved by the interim compliance dates.

Interim goals are identified for each expression of WQBELs and each weather condition. Bacteria TMDL wet and dry weather interim compliance is calculated as the halfway point between the existing, 2002 conditions and the final TMDL target. The MS4 Permit allows an alternative interim compliance date from the original Bacteria TMDL compliance date (MS4 Permit, Attachment E). Interim compliance of receiving water or effluent limitations is most reasonably attained in FY24 for wet weather and FY19 for dry weather. Updates to existing programs, changes in municipal ordinances, and collaboration within jurisdictions, WMAs, and the region have been occurring since the Bacteria TMDL and the 2013 MS4 Permit were adopted and are ongoing. Through CLRP and Water Quality Improvement Plan development, planning efforts are underway, including measures to secure funding and increase general momentum to implement and expand storm water and water conservation measures. The alternative compliance dates allow for the success of the monitoring, assessment, and goal and strategy adaptation process detailed within this Water Quality Improvement Plan.

The TMDL model used data through 2002, which is why 2002 is considered the existing condition. The existing condition does not necessarily reflect current conditions, nor is it the Water Quality Improvement Plan baseline for all goals. The existing condition for load reductions is assumed to be 0% in 2002, as that was the beginning of implementation planning. The Bacteria TMDL estimated the 2002 existing exceedance frequency for wet weather since wet weather data was not available. The MS4 permit requires the dry weather exceedance frequency to be calculated and presented in the Water Quality Improvement Plans. For each indicator bacteria, available monitoring data collected between January 1, 1996 and December 31, 2002 was assessed and compared to 30-day geometric mean WQOs.

Table H-4 presents the existing condition for the receiving water and effluent limitations and the interim TMDL compliance target for San Dieguito River. The Bacteria TMDL estimates that the 2002 wet weather exceedance frequencies for fecal coliforms, *Enterococcus*, and total coliforms were 43 percent, 49 percent, and 44 percent, respectively, based on modeling results. To calculate dry weather exceedance frequencies, 118 results were available for *Enterococcus* and 116 results each for fecal coliforms and total coliforms between 1996 and 2002. The exceedance frequency (percent of dry weather days exceeding the WQO) was 17% for *Enterococcus*, 11% for fecal coliforms, and 6% for total coliforms. Interim compliance is 50% of the existing condition.

Table H-4
Existing Conditions and Interim TMDL Targets for San Dieguito River WMA

Bacteria Indicator	Receiving Water Exceedance Frequency		Effluent Load Reduction		Interim Compliance Date
	Existing 2002 Condition	Interim Compliance[1]	Existing 2002 Condition	Interim Compliance[1]	
Wet Weather					
Fecal coliform	43%[2]	33%	0%	0.8%[2]	April 4, 2024
Enterococcus	49%[2]	36%	0%	3.9%[2]	
Total coliform	44%[2]	33%	0%	2.2%[2]	
Dry Weather					
Fecal coliform	11%[3]	5.5%	0%	10.4%[2]	April 4, 2019
Enterococcus	17%[3]	8.5%	0%	41.8%[2]	
Total coliform	6%[3]	3.0%	0%	7.2%[2]	

Note:
1. Interim compliance is calculated as 50% between the existing condition and the final TMDL target.
2. Source: Bacteria TMDL
3. Source: Monitoring data
% = percent; N/A = not applicable

The difference between the existing dry weather exceedance frequency and the dry weather load reduction highlights the shortcomings of dry weather modeling based on limited observed data. Uncertainties in the model may result in a potential disconnect between receiving water quality and watershed loading estimates. An exceedance frequency of less than 20% based on monitoring data would seem to require a lower load reduction from the watershed than 80%; however this highlights the difference between concentration and load-based information which incorporates potential uncertainties in modeling dry weather flows. An 80% watershed load reduction likely overstates the actual load reduction required to meet final compliance. Regardless of the load reduction required, the primary strategy during dry weather is to eliminate dry weather flows, which will, in turn, reduce and eliminate pollutant loading. In the Water Quality Improvement Plan, dry weather reduction strategies and progress towards meeting them are more frequently discussed in terms of flow reduction, rather than load reduction. This acknowledges the related benefit to load reductions, but highlights the source or transport mechanism for dry weather implementation.

H.4 Compliance Pathways

Interim and final compliance with the Bacteria TMDL, as incorporated into the MS4 Permit, may be demonstrated by the Responsible Agencies using any one of the methods presented in the previous sections. Section 5 of the Water Quality Improvement Plan provides additional information on the monitoring that will be completed for assessment.

References

San Diego Regional Water Quality Control Board (Regional Board). 2010. *Revised TMDL for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek)*. Resolution No. R9-2010-0001. Approved February 10, 2010. http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/docs/bacteria/updates_022410/2010-0210_Bactil_Resolution&BPA_FINAL.pdf.

APPENDIX I

Jurisdictional Strategies and Schedules

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APPENDIX I. JURISDICTIONAL STRATEGIES

Strategy selection within the San Dieguito River WMA is discussed in Section 4.2.1 and Appendix J. This appendix provides the selected strategies for each Responsible Agency including the implementation approach and level of effort required. The corresponding implementation year and duration provide context for when the strategy will be implemented. Strategies not being implemented upon approval of the Water Quality Improvement Plan provide a future date for implementation or a trigger for implementation in the future. Responsible Agencies are continually collaborating with internal jurisdictional departments, other Responsible Agencies, stakeholders, and watershed groups and non-profit organizations, and these collaborating entities are presented in the jurisdictional strategies tables as well. The strategies are subject to change and will be modified through the adaptive management process, as needed.

I.1 City of Del Mar Strategies

The City of Del Mar has selected jurisdictional strategies that best suit the topography and characteristics of its jurisdiction in order to comply with Permit requirements. Del Mar's land use primarily consists of low-density residential and commercial areas, so the strategies address problematic areas associated with these characteristics. Del Mar has an irrigation control program in place to address runoff associated with residential and commercial properties; other residential BMP rebate programs such as rain barrels and downspout disconnections are not identified at this time. Despite stringent planning requirements, the jurisdiction is highly developed, and many roads have not only limited right-of-way, but also physical space for green street implementation. While green streets will be considered, options may be limited due to right-of-way constraints and bluff stabilization concerns in many parts of the City of Del Mar. The Del Mar City Council requires approval of costs before their presentation, which occurs every two years. For the purpose of this draft of the Water Quality Improvement Plan, only costs that have been Council-approved will be presented. The City of Del Mar has identified the jurisdictional strategies in Table I-1 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

Table I-1
City of Del Mar Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
Jurisdictional Strategies					
Development Planning					
All Development Projects					
DM-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-2	Train staff on LID regulatory changes during annual stormwater training.	Formal staff training implemented annually during stormwater training.	City-wide	FY16	Ongoing
DM-3	Maintain existing floor area ratio requirements to limit impervious surface areas.		City-wide	FY16	Ongoing
DM-4	Continue retention of native vegetation - New or redevelopment projects within the Lagoon Overlay Zone shall include the retention of the maximum amount of native vegetation on the site. Revegetation or landscaping of sites within the Lagoon Overlay Zone shall include the use of non-invasive, drought tolerant species native to the San Diego coastal region and which are compatible with adjacent wetland habitat species.	Refer to Municipal Code.	City-wide	FY16	Ongoing
Priority Development Projects (PDPs)					
DM-5	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-6	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP.	City-wide	FY15	Ongoing
Construction Management					
DM-7	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP; Construction site inventory updated monthly and inspections of prioritized sites are conducted biweekly year round.	City-wide	FY16	Ongoing
Existing Development					
Commercial, Industrial, Municipal, and Residential Facilities and Areas					
DM-8	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP; Programmatic inspection/maintenance frequency included in JRMP update.	City-wide	FY16	Ongoing
DM-8.1	Update minimum BMPs for commercial, industrial, and municipal existing development and enforce. Includes BMPs for water-using mobile businesses.	Refer to JRMP; minimum BMPs updated within JRMP update.	City-wide	FY16	As-needed
DM-8.2	Provide BMP factsheet to water-using mobile businesses when business license is granted.	To ensure implementation of minimum BMPs for water -using mobile businesses, when a business license is granted for a water-using mobile business, a BMP factsheet is provided.	City-wide	FY16	Ongoing
DM-8.3	Conduct property-based commercial, industrial, municipal, and residential inspections. Includes identification and addressing unmitigated incidents of power washing discharges.	Refer to JRMP. Inspections of commercial, industrial, municipal, and multi-family residential areas conducted a minimum of six times per year.	City-wide	FY16	Ongoing
DM-8.4	Update municipal swimming pool discharge ordinance to ensure discharges from swimming pools meet permit requirements.	Refer to JRMP.	City-wide	Before FY16	As needed

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
DM-9	Implement pet waste program.	Implement education and prevention program. Pet waste bag dispensers and trash bins provided in public areas. Pet waste removal occurs as part of Dog Beach maintenance.	City-wide	FY16	Ongoing
DM-10	Promote and encourage implementation of designated BMPs at residential areas.		City-wide	FY16	Ongoing
DM-10.1	Promote and collaborate with water agencies and other groups to encourage implementation of water conservation programs that improve water quality by reducing over-irrigation with smart products or turf replacement and capturing rain water in residential areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal. Collaborate with San Diego County Water Authority (SDCWA) and promote their Water Smart irrigation system checkups and turf replacement incentives.	City-wide	FY16	Ongoing
DM-11	Promote and encourage implementation of designated BMPs in commercial areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing
MS4 Infrastructure					
DM-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP.	City-wide	FY16	Ongoing
DM-12.1	Perform catch basin cleaning.	Inspect and clean catch basins annually.	City-wide	FY16	Ongoing
DM-12.2	Repair and replace MS4 components as needed to provide source control from MS4 infrastructure.		City-wide	FY16	Ongoing
DM-13	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers and identify sewer leaks and areas for sewer pipe replacement.	Refer to Sanitary Sewer Management Plan.	City-wide	FY16	Ongoing
Roads, Street, and Parking Lots					
DM-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP	City-wide	FY16	Ongoing
DM-14.1	Enhanced street sweeping by use of regenerative air vacuum sweepers.	Enhanced sweeping implemented by using regenerative air vacuum sweepers. Residential areas are swept 2x per year; primary roads (Camino Del Mar) and business district are swept 2x per month. Collection and bike lanes and medians are swept 2x per month.	City-wide	FY16	Ongoing
DM-14.2	Perform sweeping of medians on high-volume arterial roadways.	Primary roads and business district medians are swept 2x per month.	Primary roads & business district	FY16	Ongoing
Pesticide, Herbicides, and Fertilizer BMP Program					
DM-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP.	City-wide	FY16	Ongoing
Retrofit and Rehabilitation in Areas of Existing Development					
DM-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP	City-wide	FY16	Ongoing

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
Illicit Discharge, Detection, and Elimination (IDDE) Program					
DM-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-19	Conduct frequent visual outfall monitoring to identify and eliminate illicit discharges.	As part of the patrol-based program for the construction, existing development, and outfall inventories, visit outfalls a minimum of six times per year to identify and eliminate potential illicit discharges.	City-wide	FY16	Ongoing
Public Education and Participation					
DM-20	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-20.1	Continue outreach to property managers responsible for HOAs and Maintenance Districts.	As part of the patrol-based program for the residential existing development inventory, provide frequent education and contact to HOAs and maintenance districts targeting outdoor activities and trash areas.	TBD	FY16	Ongoing
DM-20.2	Continue education and outreach to reduce over-irrigation through patrol program.	Once per year outside of business hours, patrol jurisdiction for incidents of over-irrigation and leave door-hangers identifying problem areas and appropriate corrective actions.	TBD	FY16	Ongoing
DM-20.3	Conduct trash cleanups through community-based organizations involving target audiences.	In partnership with I Love a Clean San Diego, host a site in Del Mar during two beach clean-ups per year.	TBD	FY16	Ongoing
DM-20.4	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	Update City Clean Water Program website with WQIP and JRMP information and highlight what the community can do for water quality.	City-wide	FY16	As needed
DM-20.5	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences.	City-wide	FY16	Ongoing
Enforcement Response Plan					
DM-21	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing
Additional Nonstructural Strategies					
DM-22	Continue program to address and capture trash and debris.	Continue maintenance of trash guards.	City-wide	FY16	Ongoing
DM-23	Continue participating in source reduction initiatives.	Continue implementation of cigarette ban on beaches, parks and in commercial areas.	City-wide	FY16	Ongoing
DM-24	Proactively monitor for erosion and complete minor repair and slope stabilization as needed.	Post-storm monitoring is conducted to identify slope and bluff erosion in priority areas. As-needed, repairs and slop stabilization are completed.	City-wide	FY16	Ongoing
DM-25	Protect areas that are functioning naturally.	As opportunities arise, where feasible, the City will protect areas that are functioning naturally. This may include avoiding hardscape development and degradation in unpaved open space areas and creating permanent open space protections to undeveloped city-owned land.	TBD	TBD	As available

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
DM-26	Collaborate with the 22nd District Agricultural Association (Del Mar Fairgrounds) on water quality-related issues.	The City will collaborate with the 22nd DAA on water-related issues as appropriate. The DAA is a Phase II NPDES discharger and is regulated under a separate stormwater permit. The 22nd DAA discharges directly to Steven's Creek and San Dieguito Lagoon and River.	Del Mar Fairgrounds	TBD	As needed
DM-27	City will consider alternative compliance program on a case by case basis.	Refer to JRMP.	TBD	Optional	TBD
DM-28	If a regional education group for the equestrian community and property owners is developed by the County of San Diego, contribute to the effort through outreach, education, and policy measures.		TBD	Optional	TBD
DM-29	If a regional outreach program for the development community is created, provide technical education and outreach support on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Participate in the development of a regional outreach program to the development community if it occurs.	TBD	Optional	TBD
DM-30	Implement a program to require septic system maintenance practices.	Require maintenance practices.	TBD	FY17	Ongoing
DM-31	Conduct special studies	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from streams in a minimally disturbed or “reference” condition. Refer to Section 5.1 for further details.	San Dieguito River WMA	Optional	TBD
DM-31.1	Reference watershed study	Assess sources of bacteria in the watersheds using the San Diego Bacteria Source Identification and Prioritization Process developed in 2012 as part of the MS4 Permit Report of Waste Discharge process. Focus is on the beach/lagoon area of the San Dieguito River WMA, with inputs from the upper watershed also considered where relevant and necessary to identify sources of bacteria to the beach/lagoon. Refer to Section 5.1 for further details.	San Dieguito River WMA	Optional	TBD
DM-32	Coordinate with the 22nd District Agricultural Association on programs where mutual benefits to water quality may be achieved for the watershed.	Pursue opportunities for coordinated efforts with the 22nd DAA to address water quality in the watershed.	Del Mar Fairgrounds	TBD	TBD
Green Infrastructure					
DM-33	If interim load reduction goals are not met, potential opportunities for green infrastructure will be considered.	Adaptive management process.	TBD	Optional	TBD
Multiuse Treatment Areas					
Stream, Channel and Habitat Rehabilitation Projects					
DM-34	San Dieguito Wetland Restoration Project is a project that is already underway and near completion. This regional project with multi-jurisdictional involvement is discussed further in Section 4.2.5.	San Dieguito Wetland Restoration Project is a project that is already underway and near completion. This regional project with multi-jurisdictional involvement is discussed further in Section 4.2.5.	San Dieguito Wetland	Optional	TBD
Dry Weather Flow Separation and Treatment Projects					
DM-35	If interim load reduction goals are not met, dry weather flow separation and treatment projects may be considered.	Adaptive management process.	TBD	Optional	TBD

22nd DAA = 22nd District Agricultural Association; CWP = Clean Water Program; MWD = Metropolitan Water District; SDCWA = San Diego County Water Authority; TBD = will be determined during the next fiscal year.

I.2 City of Escondido Strategies

While most of City of Escondido's (Escondido) jurisdiction is located within the Carlsbad watershed, approximately 24 percent of the City's urban area is located within the San Dieguito watershed. Significant park and open space is located within this portion of the City: Kit Carson Park (285 total acres, 185 acres of preserved open space), County-owned Felicita Park (53 total acres), and Lake Hodges open space (west of Del Dios Highway and west of I-15 adjacent to Lake Hodges) totaling 662 acres.

Escondido has a storm water detention basin (Eagle Scout Lake, formerly Sand Lake) within the San Dieguito watershed, which helps prevent sediment discharges to the San Dieguito River. Regular maintenance of this basin is a significant effort, costing hundreds of thousands of dollars and requiring extensive permitting efforts. Restoration and continued maintenance of this basin has been included as a strategy for this watershed. Although structural BMP opportunities in the watershed will be evaluated, they are less of a priority in this portion of the City.

The majority of the existing development within the San Dieguito portion of Escondido is dedicated to residential and commercial purposes. It is anticipated that strategies to address these uses will be implemented by Escondido to benefit water quality within the San Dieguito watershed. The City also plans to supplement existing outreach and enforcement efforts in any drainage areas with documented persistent MS4 outfall flows. The City of Escondido has identified the jurisdictional strategies in Table I-2 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Table I-2
City of Escondido Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
ES-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, per BMP Manual requirements.	Refer to JRMP.	City-wide	FY16	Ongoing	Environmental Programs Division (EP Div) and Engineering
ES-1.1	Weekly meetings to assess compliance across divisions/departments, including stormwater, for all development projects.	EP Div meets weekly with Engineering Land Development Dept. to discuss project compliance on project submittals. Separate weekly meeting with Planning, Fire, and Engineering for co-compliance for all development during the planning stage.	City-wide	FY16	Ongoing	EP Div with Planning, Fire, and Engineering Depts.
ES-2	Amend municipal code and ordinances, including zoning ordinances, as needed to meet BMP Design Manual requirements and facilitate and encourage LID opportunities.	Implemented as needed. Update occurred FY14-15 for permit compliance.	City-wide	Prior to FY16	As needed	EP Div
ES-3	Train staff on BMP regulatory changes and BMP Design Manual.	Formal staff training implemented as needed based on changes, such as the revision of the BMP Design Manual or staff turnover. Informal training or assistance occurs continuously with communication between Environmental Programs staff and land development staff on a regular basis.	City-wide	Prior to FY16	As needed and Ongoing	EP Div, Engineering and Planning
Priority Development Projects (PDPs)						
ES-4	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div and Engineering
ES-4.1	Administer self-certification program for treatment control BMP maintenance compliance.	BMP maintenance agreements required on all PDPs. Letters sent annually to remind property managers to self-certify. Follow-up inspections conducted on some properties.	City-wide	FY16	Ongoing	EP Div
ES-5	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP. County BMP Design Manual will be used and adapted for the City.	City-wide	FY16	As needed	EP Div and Engineering
ES-6	Administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5. and Appendix M for further details.	Refer to JRMP.	City-wide	Optional	Ongoing	EP Div, Engineering and Planning

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Construction Management						
ES-7	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP; Currently the inspection rate is dependent on time of year (dry versus wet season) and priority of site (based on threat to water quality). Most frequent inspection (high priority, wet weather) is once every 2 weeks, lowest is "as-needed." Per 2007 permit requirements.	City-wide	FY16	Ongoing	EP Div with Field Engineering
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
ES-8	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP; Highest priority inspection frequency is twice a year (food/auto establishments subject to FOG inspection). Others will be inspected per permit minimums.	City-wide	FY16	Ongoing	EP Div
ES-8.1	Update minimum BMPs for existing residential, commercial, and industrial development and enforce them.	Refer to JRMP; minimum BMPs updated as part of JRMP update.	City-wide	FY16	As needed	EP Div
ES-8.2	Increased inspection for highest pollutant potential businesses.	Within SDG watershed, those facilities with the highest potential to generate bacteria (wet/dry) are inspected twice per year.	City-wide	FY16	Ongoing	EP Div
ES-8.3	Design, implement, and enforce property- and PGA-based inspections.	Will be implemented for a portion of inspections. Will likely focus on drainage areas for major MS4 outfalls with persistent flows, notably HDG 102.	TBD	FY16	Ongoing	EP Div
ES-8.4	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div
ES-8.5	Implement program to require retrofit of trash enclosures.	All applicants seeking approval for a tenant improvement, improvements to buildings, or redevelopment, are assessed for their potential to generate pollutants through their trash enclosure. If the applicant has a pollutant-generating activity on-site, a retrofit of their trash enclosure to include a roof is required. For example, a restaurant would trigger this requirement. Costs are considered when determining if the applicant is required to implement the retrofit. The retrofit is generally not required if the improvement is less than the cost of the retrofit. Determination is made on a case-by-case basis.	City-wide	FY16	Ongoing	EP Div with Engineering
ES-8.6	Water-using mobile business inspection and permitting.	Implement permitting program to ensure that water-using mobile businesses are using appropriate BMPs to prevent discharges to the storm drain drains. A permit is required for water-using mobile businesses including power-washers, mobile detailing, and organizations holding charity car washes. As part of the permit process, the applicant must schedule an inspection. The inspection requires applicants to set up their equipment and demonstrate how they will do the work. A permit is not issued until they have demonstrated that they have appropriate BMPs to manage the discharge.	City-wide	FY16	Ongoing	EP Div
ES-8.7	Implement Water Efficient Landscape Ordinance.	Refer to JRMP. Updates to landscape regulations encourage a reduction in the use of water for irrigation and reduce water waste in the form of runoff.	City-wide	FY16	Ongoing	EP Div and Planning

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
ES-9	Implement pet waste program.	Implement education and prevention program. Pet waste bag dispensers and supplies provided for neighborhood groups, dog parks, and other municipal parks.	City-wide	FY16	Ongoing	EP Div, Community Services and Public Works
ES-10	Promote and encourage implementation of designated BMPs at residential areas.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div
ES-10.1	Promote and collaborate with water agencies and other groups to encourage implementation of water conservation programs that improve water quality by reducing over-irrigation with smart products or turf replacement and capturing rain water in residential areas.	The City of Escondido collaborates with MWD and promotes their SoCal WaterSmart rebates. Rebates include; weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal. The City also collaborates with the San Diego County Water Authority (SDCWA) to promote their WaterSmart Checkups and turf replacement incentives. City of Escondido provides funding for the WaterSmart Checkups.	City-wide	FY16	Ongoing	EP Div with MWD and SDCWA
ES-11	Promote and encourage implementation of designated BMPs, including water conservation BMPs, in commercial, agricultural, and industrial areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing	EP Div with MWD
MS4 Infrastructure						
ES-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP; Catch basins cleaned annually	City-wide	FY16	Ongoing	EP Div with Public Works
ES-12.1	Implement annual open-channel cleaning and scour pond repair to reduce pollutant loads.	Implement cleaning based on priority locations and highest maintenance needs. Sites to be addressed each year will be established annually and may be prioritized based on potential for pollution reduction; implementation schedule subject to change pending prioritization. Some sites must have a biological monitor if maintained within the bird nesting season, which may limit certain work to September – January each year.	City-wide	FY16	Ongoing	EP Div with Public Works
ES-13	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	Sewer infrastructure is cleaned annually. Closed circuit televising of sewer infrastructure is completed to identify and prioritize areas in need of upgrade or slip lining. As areas for maintenance are identified, corrective action is taken.	TBD	FY16	Ongoing	Utilities Department
Roads, Street, and Parking Lots						
ES-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div with Public Works
ES-14.1	Perform street sweeping.	Refer to JRMP; High priority areas swept twice per month. Medium priority areas swept once per month. Low priority areas swept as needed.	TBD	FY16	Ongoing	EP Div with Public Works

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
ES-14.2	Perform sweeping of medians on high-volume arterial roadways.	Refer to JRMP; Medians swept according to priority area frequency. Medians in high priority areas swept twice per month; medium priority areas swept once per month; and in low priority areas swept as needed.	TBD	FY16	Ongoing	EP Div with Public Works
Pesticide, Herbicides, and Fertilizer BMP Program						
ES-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP. City does not have authority over application of pesticides, but will implement BMPs. Water conservation activities encourage residential and commercial area BMPs. Industrial and commercial inspections cover requirement. Parks and Recreation implement the municipal program.	City-wide	FY16	Ongoing	EP Div with Public Works
Retrofit and Rehabilitation in Areas of Existing Development						
ES-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP.	City-wide	None	Ongoing	EP Div with Engineering and Public Works
ES-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP.	City-wide	Identify during JRMP update	Ongoing	EP Div with Engineering, Public Works, RWQCB, CDFW, Army Corps of Engineers
Illicit Discharge, Detection, and Elimination (IDDE) Program						
ES-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div
ES-18.1	Implement "We Care" Program for employee reporting of potential illicit discharges.	Continue supporting the city-wide "We Care" program which encourages employees to report problems that they observe throughout the City. Reports of irrigation issues are currently included. In FY16, updates to specifically include and encourage reporting of other storm water related issues will be complete.	City-wide	FY16	Ongoing	EP Div with City Manager's office
ES-18.2	Use "Report It" smartphone application to encourage residents to report potential illicit discharges or other storm water violations.	Continue supporting the city-wide "Report It" smart phone application which encourages the public to report problems that they observe throughout the City, including potential illicit discharges and other storm water related violations.	City-wide	FY16	Ongoing	EP Div with Information Systems and City Manager's office
Public Education and Participation						
ES-19	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div
ES-19.1	Expand outreach, training, and incentive programs to homeowners' associations (HOAs).	Investigate expansion of municipal outreach programs and collaboration with MWD and SDCWA to expand incentive programs targeting landscape practices and turf replacement programs.	TBD	FY16	Ongoing	EP Div

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
ES-19.2	Conduct trash cleanups through community-based organizations involving target audiences.	Continue implementation of "We Clean Escondido" program targeting litter removal. "We Clean Escondido" programs encourage groups to adopt their neighborhood and conduct weekly litter removal events. Continue collaboration with "I Love a Clean San Diego" to host two Creek to Bay Cleanups at Dixon Lake, or other locations in Escondido.	TBD	FY16	Ongoing	EP Div
ES-19.3	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	City-wide	FY16	Ongoing	EP Div with Information Systems
ES-19.4	Continue partnership with MWD to provide rebates for water efficient products to large businesses and agricultural customers.	Continue partnership with MWD to provide rebates for water efficient products to large businesses and agricultural customers. Continue Water Savings Incentive Program and Conservation Programs through support for rebates such as rotating irrigation nozzles, residential smart controllers, rain barrels, soil moisture sensor systems and incentives such as turf replacement program, SoCal water smart turf removal program, WaterSmart checkups, California friendly landscape training classes, WaterSmart landscape makeover workshops, and garden friendly plant fairs.	City-wide	FY16	Ongoing	EP Div with MWD
ES-19.5	Enhance school and recreation-based education and outreach	Partner with organizations such as the Escondido History Center, Humane Society, the Chamber of Commerce, and the Downtown Business Association to host education events targeting adults and children through the year. Continue with robust school outreach program. Program targets 6-12 yrs. during the school year. In the summer, the program targets 6 to 12 year olds in coordination with various summer camps. Two presentations are given on one day, weekly, throughout the summer.	City-wide	FY16	Ongoing	EP Div with various community organizations (including, but not limited to, the Humane Society, the Escondido History Center, the Chamber of Commerce and schools)
ES-19.6	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences	City-wide	FY16	Ongoing	EP Div with regional education and outreach campaigns
ES-20	Municipal staff training	Conduct mandatory training for all new City employees. Engage new employees with storm water jeopardy game reinforcing training on watersheds, the MS4, and MS4 permit requirements.	City-wide	FY16	Ongoing	EP Div
ES-21	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Provide outreach materials to the development community on the City's website, written material and in person education at the City's Development Services counter.	City-wide	FY16	Ongoing	EP Div with Engineering
Enforcement Response Plan						
ES-22	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing	EP Div with Code Compliance and Engineering

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Additional Nonstructural Strategies						
ES-23	Conduct special studies	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for "natural sources" to establish the concentrations or loads from streams in a minimally disturbed or "reference" condition. Refer to Section 5.1 for further details.	City-wide	TBD	TBD	TBD
ES-23.1	Reference watershed study	Assess sources of bacteria in the watersheds using the San Diego Bacteria Source Identification and Prioritization Process developed in 2012 as part of the MS4 Permit Report of Waste Discharge process. Focus is on the beach/lagoon area of the San Dieguito River WMA, with inputs from the upper watershed also considered where relevant and necessary to identify sources of bacteria to the beach/lagoon. Refer to Section 5.1 for further details.	City-wide	FY16	TBD	EP Div with regional copermittees
ES-24	Collaborate with the City of San Diego Lake Hodges source investigations effort	The City of San Diego's Public Utilities Department will conduct studies that can characterize the nutrient budget or "loading rate" for Lake Hodges. Escondido will participate in collaborative watershed efforts.	TBD	FY17	2 yrs.	Utilities Department with City of San Diego
ES-25	Mapping and assessment of agricultural operations.	Prepare and maintain a figure of the locations of agricultural operations in Escondido. Identify agricultural land close to receiving waters and/or MS4 system and conducting a site reconnaissance to assess if discharges are likely to occur and develop a series of follow-up actions specific to those risks.	TBD	TBD	As needed	EP Div
ES-26	Proactively repair and replace corrugated metal pipe (CMP) MS4 components to provide source control from MS4 infrastructure.	This strategy is unfunded and there is no firm timeframe for development. The timeframe for this strategy will be updated in future WQIP updates, as funding becomes available	TBD	TBD	Ongoing	Engineering
ES-27	If a regional social services effort is established, support workgroup to provide sanitation and trash management for person experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	If a regional effort is established, participate in workgroup and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	TBD	Optional	TBD	EP Div
ES-28	If invasive plant and animal removal is necessary in key locations, collaborate with Urban Corps of San Diego or other volunteer groups as needed.	If opportunities for collaboration with the Urban Corps of San Diego or volunteer groups arise for the removal of invasives at key locations, then the City will try to take advantage of the opportunity.	TBD	Optional	As needed	EP Div with Public Works
ES-29	Participate in a Felicita Creek Subwatershed Group	Should citizens choose to pursue such a group, the City will participate in a forum dedicated to addressing issues specific to Felicita Creek, especially those issues which can be resolved through group collaboration (e.g. invasive species removal).	TBD	TBD	As needed	EP Div with Public Works

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Multiuse Treatment Areas						
Stream, Channel and Habitat Rehabilitation Projects						
ES-30	Eagle Scout (formerly Sand) Lake Project	Eagle Scout Lake (formerly Sand Lake) is an existing multiuse treatment area and sediment detention basin in the City of Escondido. A major restoration project in early 2014 improved water flow, water quality issues (providing capacity for sediment settlement) and health and safety issues (vector control). The project drains the water from Kit Carson Creek and an adjacent ephemeral stream an area of approximately 4 acres. It is anticipated to be regularly maintained as needed, current estimates are once every five years, but will be determined on visual evaluation.	TBD	Prior to FY16	FY13-14	EP Div with Public Works
Green Infrastructure						
ES-31	If interim load reduction goals are not met and additional green infrastructure is required, approximately 26.15 acres of available space have been identified as potential opportunities for green infrastructure implementation on public parcels.	If monitoring data suggests that it is unlikely that goals will be met using the strategies identified for implementation through FY20, construction, operation and maintenance potential green infrastructure projects on public parcels will be investigated by initiating planning and assessing feasibility for 25% of the total parcel acreage identified.	TBD	Optional	TBD	EP Div
Green Streets						
ES-32	If interim load reduction goals are not met and additional green infrastructure is required, potential opportunities for green infrastructure implementation will be evaluated.	Construction, operation, and maintenance of green streets, if and where feasible, and as funding allows.	TBD	Optional	TBD	EP Div

EP Div = Environmental Programs Division; MWD = Metropolitan Water District; SDCWA = San Diego County Water Authority; TBD = will be determined during the next fiscal year.

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I.3 City of Poway Strategies

The City of Poway, located in the middle of the watershed, tends to have larger lot sizes and more pervious surfaces. Strategies focus on source control, such as open trash enclosures and a public waste yard, through monitoring and reducing the pollutant source exposure and storm water runoff, in addition to administrative JRMP strategies. The City of Poway has identified the jurisdictional strategies in Table I-3 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Table I-3
City of Poway Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
PW-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Priority Development Projects (PDPs)						
PW-2	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
PW-3	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP.	City-wide	FY16	As needed	DSD
PW-3.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover.	Implemented through the Minor Development Review process and the plan check process.	City-wide	FY16	As needed	DSD
PW-4	Administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5. and Appendix M for further details.	Refer to JRMP.	City-wide	FY16	As needed	DSD
Construction Management						
PW-5	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP; Perform daily inspections during construction.	City-wide	FY16	Ongoing	DSD
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
PW-6	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP; Commercial/industrial/municipal are inspected annually, with municipal receiving more frequent inspections by staff.	City-wide	FY16	Ongoing	DSD
PW-6.1	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	Annually review policies and procedures.	City-wide	Prior to FY16	As needed (Annually)	DSD
PW-6.2	Track stationary and mobile businesses through communication with Business Licensing Division.	Maintain through the City's Commercial/Industrial program.	City-wide	FY16	Ongoing	DSD with Administrative Services
PW-7	Promote and encourage implementation of designated BMPs with all new construction.		City-wide	FY16	Ongoing	DSD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-7.1	Promote MWD and other groups to encourage implementation of water conservation programs that improve water quality by reducing over-irrigation with smart products or turf replacement and capturing rain water in residential areas.	Collaborate with MWD to promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal. Collaborate with San Diego County Water Authority (SDCWA) to promote their Water Smart irrigation system checkups and turf replacement incentives.	City-wide	FY16	Ongoing	DSD with MWD and SDCWA
PW-8	Promote and encourage implementation of designated BMPs in commercial areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing	DSD with MWD
PW-9	Implement program to investigate illegal grading on private property.	Program to investigate reports of illegal grading. Maintain records of reported illegal gradings and immediately investigate. If activity violates grading or stormwater regulation, issued a "Stop Work" notice and must obtain grading permit and correct stormwater violations. Reports are tracked in "Trackit" software as a code violation and bi-monthly meetings to discuss the status of reports. Grading cases are subject to a strict timeline of action, and enforcement is upped until either compliance, or a Notice of Violation is filed against the property. If it is a stormwater issue, the City's on-call stormwater contractor corrects the issue and City liens the property for payment.	City-wide	FY16	Ongoing	DSD
PW-10	Reconfiguring DPW waste yard to reduce pollutants/runoff.	Follow the site's SWPPP and perform annual monitoring. Relocate activities to limit exposure to reduce pollutants and runoff.	City-wide	FY16	Ongoing	DSD with DPW
MS4 Infrastructure						
PW-11	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP.	City-wide	FY16	Ongoing	DSD with DPW
PW-11.1	Perform catch basin cleaning.	Inspect and clean catch basins annually.	City-wide	FY16	Ongoing	DPW
PW-11.2	Clean open-channels and repair scour ponds to reduce pollutant loads and invasive plants and animals.	Inspect and clean open channels and scour ponds.	City-wide	FY16	Ongoing	DPW
PW-11.3	Proactively repair and replace corrugated metal pipe (CMP) MS4 components to provide source control from MS4 infrastructure.	Implement CMP replacement program with an emphasis on pipes in open canyons.	City-wide	FY16	Ongoing	DSD with DPW
PW-12	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers and identify sewer leaks and areas for sewer pipe replacement.	Program implemented through sewer maintenance and inspection program.	City-wide	FY16	Ongoing	DSD with DPW
Roads, Street, and Parking Lots						
PW-13	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP; The City of Poway is divided into 7 zones for road operation and maintenance activities; rotational cycle: one zone inspected each year	City-wide	FY16	Ongoing	DSD with DPW
PW-13.1	Implement street sweeping.	Refer to JRMP; all areas swept twice per month.	City-wide	FY16	Ongoing	DPW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-13.2	Increase maintenance on access roads by proactively monitoring for erosion and completing minor repair and slope stabilization.		City-wide	FY16	Ongoing	DSD with DPW
PW-13.3	Increase maintenance on access trails by proactively monitoring for erosion and completing minor repair and slope stabilization.		City-wide	FY16	Ongoing	DSD with DPW
Pesticide, Herbicides, and Fertilizer BMP Program						
PW-14	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Retrofit and Rehabilitation in Areas of Existing Development						
PW-15	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.		City-wide	TBD	Ongoing	DSD
PW-16	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.		City-wide	TBD	Ongoing	DSD
Illicit Discharge, Detection, and Elimination (IDDE) Program						
PW-17	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Public Education and Participation						
PW-18	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
PW-18.1	Target school-based education and outreach.	Through "I Love a Clean San Diego," give school presentations to fourth-graders eight times per year.	City-wide	FY16	Ongoing	DSD with I Love a Clean San Diego
PW-18.2	Conduct education through community-based organizations.	Through "I Love a Clean San Diego," staff street fair booths twice per year.	City-wide	FY16	Ongoing	DSD with I Love a Clean San Diego
PW-18.3	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	Review City storm water website, identify and implement required updates to reflect WQIP and JRMP revisions.	City-wide	Prior to FY16	As needed	DSD
PW-18.4	Target human behavior in parks and other public areas including trash reduction or other high impact behavior to habitat, wildlife, and water quality.	Implement trash reduction programs by increasing the number of trash and recycling bins during high-traffic public events and in public parks.	City-wide	FY16	Ongoing	DSD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-18.5	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences.	City-wide	FY16	Ongoing	DSD with regional education and outreach campaigns
Enforcement Response Plan						
PW-19	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Additional Nonstructural Strategies						
PW-20	Conduct special studies.	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from streams in a minimally disturbed or “reference” condition. Refer to Section 5.1 for further details.	City-wide	TBD	TBD	DSD
PW-20.1	Reference watershed study.	Los Peñasquitos WMA special study will assess sediment loads in the watersheds upstream of the Draft Sediment TMDL compliance monitoring locations. Includes the analysis of sediment water column loads, stream bedload, and air monitoring. Implemented in a phased approach. Monitoring will occur first in the Carroll Canyon subwatershed. The Los Peñasquitos Creek and Carmel Valley Creek subwatersheds will be monitored in subsequent phases. Refer to Section 5.1 for further details.	City-wide	FY16	Ongoing	DSD
PW-21	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and acquiring privately-owned undeveloped open areas.	As opportunities arise, where feasible, avoid hardscape development and degradation in unpaved open space areas, create permanent open space protections to undeveloped city-owned land, and acquire privately owned undeveloped parcels of land.	TBD	Optional	As available	DSD
Green Infrastructure						
PW-22	If interim load reduction goals are not met and additional green infrastructure is required, 74 acres of available space have been identified as potential opportunities for green infrastructure implementation on public parcels.	Construction, operation and maintenance of 74 total parcel acreage of potential green infrastructure projects on public parcels.	TBD	Trigger	TBD	DSD
Multiuse Treatment Areas						
PW-23	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin can be implemented near Chaparral Elementary School.	There are 4.4 acres available to construct an infiltration basin to treat 45.5 acres of primarily single-family residential areas.	Near Chaparral Elementary School	Trigger	TBD	DSD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-24	If interim load reduction goals are not met and additional multiuse treatment areas are required, a subsurface detention basin can be implemented on the grounds of Painted Rock Elementary School.	Painted Rock Elementary has about 2.2 acres available for a subsurface detention basin that could potentially treat 164 acres of residential areas.	Painted Rock Elementary School	Trigger	TBD	DSD

DSD = Development Services Department; DPW = Department of Public Works; MWD = Metropolitan Water District; SDWCA = San Diego County Water Authority; TBD = will be determined during the next fiscal year.

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I.4 City of San Diego Strategies

The City has identified water quality improvement strategies that are expected to provide the greatest benefits to the watershed and its residents, businesses, communities within the City's jurisdictional boundaries.

Strategies were selected by evaluating the following considerations, in descending priority:

- Potential to reduce pollutant loads for the highest priority condition condition(s)
- Potential to reduce loads for other pollutants (including priority water quality conditions)
- Cost effectiveness
- Feasibility and ease of implementation
- Social impacts and benefits
- Other[1] impacts and benefits

The strategies that provide the best value, most return on investment, and greatest range of benefits will be recommended, as needed, as the City moves forward in its water quality improvement efforts. The recommended strategies identified are consistent with those already identified in the Comprehensive Load Reduction Plans (CLRPs) for various TMDLs in the San Diego Region.

The City is currently developing a framework to evaluate potential other benefits the recommended strategies may provide beyond improved water quality. These additional benefits may be financial, environmental, or societal. The recommended strategies will be scored based on the number of other benefits they provide, and may guide future updates to the Water Quality Improvement Plan (Appendix M).

The cumulative storm water quality benefits of the Recommended Strategies identified in this Plan are needed to achieve the level of effort needed to demonstrate progress toward achieving the Water Quality Improvement Plan's (Plan) interim and final numeric goals. It is important to note that these strategies are subject to change through the iterative, adaptive management process set forth in this Water Quality Improvement Plan. Through the adaptive management process the Responsible Agencies will be able to implement strategies and assess their impact to water quality and use new available information to refine, modify, remove, replace, or add strategies which will ensure the most effective suite of strategies are being implemented. Therefore, actual implementation of strategies is dependent upon both approval of funding in future annual budgets and adjustments that may occur as part of the iterative process.

The recommended strategies selected are presented in Table I-4. These strategies will be implemented by the City; they are not intended to be implemented by private entities

[1] Other benefits refer to outcomes of a strategy beyond water quality improvements. Other benefits can include reduced air pollution, increased water conservation, watershed protection, public open space, aesthetics-induced property value increases, and increased business investments.

(e.g. development, business, industry, etc.). Some of the City's strategies, such as development planning, may have implications for private entities. The City has also developed a schedule as a best estimate of the shortest amount of time required to plan and implement the strategies. The City's schedule table is found in Table I-5. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

Optional strategies are activities that may be implemented by the Responsible Agencies at their discretion through the iterative approach. Unlike the recommended strategies, optional strategies have not been determined to be necessary in order to achieve the Plan's interim and final numeric goals. However, the Responsible Agencies may select from the optional strategies if the current suite of recommended strategies is not demonstrating sufficient progress toward achieving interim or final numeric goals, and if other identified triggers are met.

Table I-4
City of San Diego Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
CSD-1	Establish guidelines and standards for all development projects; provide technical support related to implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area or implement easements to protect water quality, where applicable and feasible. Includes internal coordination and collaboration between City departments (DSD, PWD, and Engineering) to improve success and long-term benefits of BMPs.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.1	Investigation and research of emerging technology.	Annually the Construction & Development Standards Group identifies new tasks to conduct literature review, communication with researchers outside of the City, physical testing and experimentation of new or emerging technologies, and other research with the goal of updating tools available for reducing pollutant loads from development and redevelopment sites.	City-wide	Prior to FY16	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.2	Approve and implement a green infrastructure policy.	The City will begin developing a policy in FY16 that will increase the green infrastructure requirements for City CIP projects. This policy will be coordinated with ongoing efforts to update City design manuals and LID design standards for public LID BMPs.	City-wide on public parcels	FY16 (Begin)	As needed	T&SW with DSD and PWD
CSD-1.3	Develop Design Standards for Public LID BMPs.	Improve quality of design to ensure efficiency and reliability in public designs.	City-wide	FY14-FY15	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.4	Outreach to impacted industry regarding minimum BMP requirement updates.	Affects commercial, industrial, and residential development.	City-wide	FY15	As needed	TBD
CSD-2	Train staff on LID regulatory changes and LID practices.	Formal training is required for all staff involved in development plan review to increase knowledge of LID BMPs. Goal of training associated with LID practices and regulations is to promote LID implementation and to avoid adverse conditions such as trees planted within swales, or planned drainage patterns which obstruct or inhibit LID performance.	City-wide	FY16	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-3	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities to support compliance with the MS4 Permit and TMDLs in a reasonable manner. Ensure consistency with the City of San Diego's BMP Design Manual. Update the Storm Water Standards Manual accordingly.	Municipal codes and ordinances will be brought to City Council for consideration to encourage LID implementation (e.g., runoff detention and filtration using natural filters and stormwater retention for reuse). LID stormwater management will be encouraged in proposed codes and ordinances associated with development and redevelopment projects, which are brought to City Council for consideration.	City-wide	FY15	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-4	Create a manual that outlines right-of-way design standards.	Create a manual that includes flood control performance standards, permanent BMP elements design standards, design standards for green streets and other BMPs, and maintenance access. Provides drainage and streets design standards. Opportunity to merge various existing manuals and provide consistency.	City-wide	FY15	One time	T&SW with DSD and PWD
CSD-5	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Technical education and outreach to the development community includes outreach on design standards, City design manuals, and the WMAA.	City-wide	Prior to FY16	Ongoing	T&SW with DSD
Priority Development Projects (PDPs)						
CSD-6	For PDPs, provide technical support to other City departments to ensure implementation of on-site structural BMPs to control pollutants and manage hydromodification by developing City wide storm water development standards and design guidelines.	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing structural BMPs that control pollutants and manage hydromodification. Included in that understanding are requirements to confirm proper design and construction through processes controlled by other City departments.	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-6.1	Institute a program to verify and enforce maintenance and performance of treatment control BMPs.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP (currently under development).	City-wide	FY15	Every 5 years/ permit cycle	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.	Amend BMP Design Manual and zoning standards/requirements which address reduction of pollutants for common areas of trash build-up (e.g. restaurants, supermarkets, "big box" retail stores with food, pet stores). Most effective method for source control of bacteria and trash is to employ four-sized trash enclosures with a cover over trash areas.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.2	Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.	Amend BMP Design Manual and zoning requirements (including retrofits) to provide supplemental standards for animal facilities (including animal shelters, dog daycares, veterinary clinics, groomers, pet car stores, and breeding, boarding, and training facilities). Supplemental standards may include requiring covered trash enclosures, identification of landscaped relief areas on site plans, ensuring drainage connections and treatment swales for areas that will not drain to the sanitary sewer, as well as inspection of grading, drainage, and landscaping for outdoor exercise areas.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-7.3	Amend BMP Design Manual for nurseries and garden centers.	Amend BMP Design Manual to provide supplemental standards for plant nurseries and garden centers. Standards will focus on reducing irrigation runoff, and loading of sediment, pesticides, and nutrients. Measures may include: covered outdoor storage, green waste management BMPs, improved irrigation efficiency to reduce dry-weather runoff, and containment of runoff from impervious areas where plants and materials are stored.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.4	Amend BMP Design Manual for auto-related uses.	Amend BMP Design Manual to provide supplemental standards for automotive-related uses to reduce loading of metals, oils, grease, and trash. Measures may include: four-sized covered trash enclosures, and careful review of auto-related usage areas (e.g. garage bays at repair shops) for grading, drainage, and drain connections to sanitary sewer systems.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-8	Develop and administer an alternative compliance program for on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5.	Refer to JRMP (currently under development).	City-wide	FY15	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-8.1	Create a fund that allows habitat acquisition, protection enhancement, and restoration in conjunction with other cooperating entities including community groups, academic institutions, state county, and federal agencies, etc.	This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Construction Management						
CSD-9	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing temporary BMPs that control sediment and other pollutants during the construction phase of projects. Included in that understanding are requirements to inspect at appropriate frequencies and effectively enforce requirements through process controlled by other City departments.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
CSD-10	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PUD, & PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-10.1	Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include required street sweeping, catch basin cleaning, and maintenance of private roads and parking lots in targeted areas.	Refer to JRMP (currently under development).	City-wide	FY15	Every 5 years	T&SW
CSD-10.2	Outreach to property managers and trash haulers to elevate the emphasis of power washing as a pollutant source.	Emphasis will be placed on non-compliant washing as an enforceable violation.	City-wide Residential, commercial and industrial areas	FY15	Ongoing	T&SW
CSD-10.3	Implement property based inspections.	Property-based inspections increase awareness and responsibility for individual properties to tackle issues associated with trash, landscapes, and parking areas. Expanding beyond the business-level inspections will achieve different and more effective opportunities for education, outreach, inspection, and enforcement to encourage water conservation strategies.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-10.4	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	Verify and bring to City Council for consideration an update (as needed) for the City's Municipal Code (43.0301) to meet new permit requirements for swimming pool discharges.	City-wide	FY15	As needed	T&SW, City Attorney (Civil & Criminal)
CSD-11	Promote and encourage implementation of designated BMPs for residential and non-residential areas.	Landscape-based rebates are a "gateway" for adoption of other beneficial practices and are one of the nonstructural methods which address impacts from single-family residential areas (City of San Diego 2011 program development background study). Residential incentives can include: education and training (neighborhood watershed field days), and aggressive subsidies or rebates for grass replacement and rainwater harvesting. Existing programs will be expanded overall, and also have targeted expansion within specific subwatershed, particularly with highest water quality priority conditions.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, MWD, CWA & local water agencies
CSD-11.1	Residential and Commercial BMP: Rain Barrel	The existing PUD rebate program will continue for residential properties and expand for commercial properties for water collection, conservation, and reuse with rain barrels.	City-wide Residential Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.2	Residential and Commercial BMP: Grass Replacement	The existing PUD grass replacement cash rebate program will continue and expand for residential and commercial properties. Program encourages a reduction in water use through the conversion of non-artificial grass to water wise plant material, while maintaining a high level of living landscape to benefit the environment.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.3	Residential and Commercial BMP: Downspout Disconnect	Disconnecting downspouts provide alternate runoff pathways from rooftops, sidewalks, driveways, and roads. Disconnecting downspouts from residential areas to pervious land can allow for depression storage and infiltration.	City-wide Residential and Commercial Areas	FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.4	Residential and Commercial BMP: Microirrigation	The existing PUD micro-irrigation rebate program will continue and increase for residential and commercial properties. Application of microirrigation aims to improve the efficiency of landscape irrigation through the precise application of water.	City-wide Residential Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-11.5	Provide Onsite Water Conservation Surveys.	Provide free onsite water conservation surveys to commercial and residential customers to reduce overirrigation and to encourage water conservation.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
MS4 Infrastructure						
CSD-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, channels as allowed by resource agencies, detention basins, etc.) for water quality improvement and for flood control risk management.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW
CSD-12.1	Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.	In order to limit inflow of pollutants and reduce pollutant loads, proactive measures will be taken to improve, repair, and replace MS4 components. The City of San Diego will start a multi-year program of repairing and replacing storm drain pipes to reduce sediment loading to the MS4. Development of an assessment management program and bond issues will be addressed. Exploration of daylighting pipes will take place where feasible and appropriate.	City-wide	FY16	Ongoing	T&SW
CSD-13	Coordinate with other City departments (PUD) to implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with PUD
CSD-13.1	Identify sewer leaks and areas for sewer pipe replacement prioritization.	Risk assessment to include identifying targeted areas (age, location, proximity to MS4), coming up with methodology, pilot, desktop exercise/analysis.	City-wide	FY16	As needed	T&SW with PUD
Roads, Street, and Parking Lots						
CSD-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW
CSD-14.1	Initiate sweeping of medians on high-volume arterial roadways.	Medians of roadways are also a potential source of pollutants. Consider implementing or increasing sweeping of medians. Consider mechanical and hand sweeping techniques.	City-wide	FY17	Ongoing	T&SW
Pesticide, Herbicides, and Fertilizer BMP Program						
CSD-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with Parks and Rec

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Retrofit and Rehabilitation in Areas of Existing Development						
CSD-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP (currently under development). The Offsite Alternative Compliance Program will include methods for identifying and assessing potential retrofit projects in existing development areas. Retrofit project selection will be based upon a variety of factors including proximity to high priority water quality conditions, potential pollutant load removal effectiveness, and feasibility of implementation. The program will include protocols related to funding mechanisms for project construction and long-term maintenance, payment and credit structures, and water quality equivalency standards.	City-wide	TBD	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP (currently under development). The Offsite Alternative Compliance Program (Section 4.2.5.3 and Appendix M) will include methods for identifying and assessing potential stream, channel, or habitat rehabilitation projects in existing development areas. Rehabilitation project selection will be based upon a variety of factors including existing stream or habitat degradation, potential future cumulative stream or habitat impacts, and feasibility of implementation. The program will include protocols related to funding mechanisms for project construction and long-term maintenance, payment and credit structures, and water quality equivalency standards.	City-wide	TBD	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Illicit Discharge, Detection, and Elimination (IDDE) Program						
CSD-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW
Public Education and Participation						
CSD-19	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW
CSD-19.1	Continue implementation of a Pet Waste Program.	Pet Waste Program includes outreach on "Scoop the poop", installation of posts for dispensers, distribution of lawn signs, and attendance at dog-related community activities.	City-wide	Prior to FY16	Ongoing	T&SW with Parks and Rec
CSD-19.2	Promote and encourage implementation of designated BMPs in commercial and industrial areas.	Provide education and outreach on BMPs for commercial businesses and industrial facilities.	City-wide Non-residential Areas	Prior to FY16	Ongoing	T&SW with PUD; Funding: Prop 84 and water districts (MWD)

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-19.3	Expand outreach to homeowners' association (HOA) common lands and HOA incentives.	Approaches to consider include: offering incentives to HOAs and maintenance districts to adopt water-conserving/efficiency and stormwater-reduction changes to their landscapes, irrigation, and maintenance; conducting workshops with property managers; providing supplemental standards, inspection, or enforcement for HOA-managed properties.	City-wide	FY16	Ongoing	T&SW
CSD-19.4	Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.	Approaches to engage HOAs and property managers include: conducting workshops with property managers, providing supplemental standards, inspections or enforcement around HOA properties, and offering incentives to HOAs and maintenance districts to adopt changes to landscapes, irrigation, or maintenance which promote water conservation or stormwater reduction. Property managers are also a target for enhanced outreach.	City-wide	FY16	Ongoing	T&SW
CSD-19.5	Enhance and expand trash cleanups through community-based organizations involving target audiences.	Increase effectiveness and reach of trash/beach cleanups and community based efforts by engaging community groups to self-define and carry-out trash clean-ups. Longstanding partnerships and sponsorships with I Love A Clean San Diego and others are recommended to be continued and enhanced. To effectively target stream clean-up efforts, focus on partnerships with community organizations which provide strong engagement with target audiences and communities.	City-wide	FY16	Ongoing	T&SW and Parks and Rec
CSD-19.6	Improve consistency and content of websites to highlight enforceable conditions and reporting methods.	Websites will be updated to provide a user-friendly format and clarity for stormwater violations, conditions which citizens can and should report, and how to make such reports. Examples of reports for common incidents will be developed and posted which may vary locally and regionally. Photographs of allowable practices as well as illegal practices should be shown for utmost clarity. Displaying hotline numbers prominently on the website and near the photographs of illegal practices will ensure that those seeking to report will be able to do so easily. Also ensure hotline number and website are searchable and can be retrieved by simple internet searches.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-19.7	Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.	Educate residents on practices of small-scale or on-site composting to protect local water quality. May include targeted education of owners of chickens. Outreach can be coordinated through the San Diego County Agriculture, Weights, and Measures division.	San Dieguito River WMA	FY16	Ongoing	T&SW with County of San Diego Ag, Weights, and Measures
CSD-19.8	Enhance school and recreation-based education and outreach.	Develop curriculum and establish distribution in public schools. Includes education on water conservation.	City-wide	FY15	Ongoing	T&SW, PUD with community-based organization
CSD-19.9	Develop education and outreach to reduce irrigation runoff.	Example approaches to reduce or eliminate irrigation runoff may include: education and outreach, prohibition, enhanced enforcement of existing prohibitions, and pilot projects such as the City of Del Mar's pilot door hanger project.	City-wide	Prior to FY16	Ongoing	T&SW with PUD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-19.10	Develop regional training for water-using mobile businesses.	Consider development of supplemental standards for mobile businesses including: covered trash enclosures, careful review of washing areas (grading, drainage, landscaping, sanitary sewer system connectivity), and appropriate signage (either through zoning for retrofits or "best fix" approaches, or through BMP Design Manual standards). Businesses may include carpet cleaners, tile installers, plumbers, etc.	City-wide	FY16	Ongoing	T&SW
CSD-19.11	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	Use effectiveness surveys to enhance existing education and outreach programs while proactively keeping up with and incorporating changing regulatory requirements.	City-wide	FY16	Ongoing	T&SW
CSD-19.12	Continue to promote and encourage implementation of Integrated Pest Management (IPM) for residents and businesses.	The City will continue to provide education on IPM techniques during presentations and on the City's Think Blue website.	City-wide	Prior to FY16	Ongoing	T&SW
Enforcement Response Plan						
CSD-20	Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Storm Water Code Enforcement Unit's Standard Operating Procedures (SOPs) - Enforcement Response Plan.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW with PUD, other City enforcement compliance programs
CSD-20.1	Increase enforcement of irrigation runoff.	Increased enforcement policies against irrigation runoff will be established in tandem with the education and outreach programs on how these actions lead to pollutant loading. By shifting to property-based inspections irrigation runoff can be handled as enforceable violations once the public is well-informed.	City-wide	FY16	Ongoing	T&SW
CSD-20.2	Increase enforcement of water-using mobile businesses.	In addition to education, pollution associated with mobile business sources can be handled through policy, code development, inspections of business practices, and enforcement.	City-wide	FY16	Ongoing	T&SW
CSD-21	Increase enforcement of all minimum BMPs for existing residential, commercial, and industrial development.	Increased enforcement of existing development minimum BMPs.	City-wide	FY16	As needed	T&SW
CSD-22	Increase enforcement associated with property-based inspections.	Shifting inspections from businesses-specific to property-based will increase effectiveness and sense of responsibility and ownership. Education and outreach must be followed up with inspection and enforcement of regulations to encourage proper landscape and water conservation strategies.	City-wide	FY16	Ongoing	T&SW
CSD-23	Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.	Refer to Minimum BMPs in JRMP.	City-wide	FY16	Ongoing	T&SW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-24	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	Eroding and unstable slope areas on private property (excluding construction sites) will be identified as potential sediment loading sources and subject to enforcement. In the short term, this will target enhanced inspection and enforcement programs to ensure inspectors address erosion and slope instability for the purpose of education.	City-wide	FY16	Ongoing	T&SW
Additional Nonstructural Strategies						
CSD-25	Conduct a Comprehensive Benefits Analysis to identify benefits other than water quality that are applicable to each of the specific WQIP strategies.	The analysis identifies which other benefits apply to each strategy, and documents the assumptions making those linkages. The delineation of other benefits to strategies includes a general description of each benefit, and a listing of the assumptions that were made to link those benefits to strategies. In addition, the other benefits are characterized with respect to who is directly affected: the city, local residents, local businesses, or visitors. This analysis may be used as part of the adaptive management process to modify future strategies.	City-wide	FY15	One time	T&SW
CSD-26	Address and clean up trash from transient encampments with collaboration from the Homeless Outreach Team.	Coordinate with the Homeless Outreach Team to respond to transient encampment trash complaints.	City-wide	FY16	Ongoing	T&SW with Police, ESD, Urban Corps, Alpha Project
CSD-27	Continue participating in source reduction initiatives.	Source reduction initiatives are ultimately the most effective measure to remove pollutants from surface waters, where feasible. Bans or progressive phase-outs that may be considered include: leaf blowers, plastic bags, architectural copper (generally a legacy issue), as well as prohibiting or more aggressively regulating vehicle washing. Additional source reduction initiatives to consider include pesticide sales at hardware stores and irrigation supply stores.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-27.1	Coordinate with Fleet Services to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available.	Consider legislative mandate and cooperative implementation of copper-free brake pads on city-owned vehicle to reduce pollutant deposition.	City-wide	FY18	Ongoing	T&SW, ESD with PWD (Fleet Services)
CSD-28	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	Actively identify and repair eroding slopes that may be contributing to sediment loading. Prepare an inventory and assessment of eroding areas and their risk to surface waters. Follow assessment with a schedule for ongoing inspection and stabilization (potentially based on a number or percentage of sites annually). Consider Caltrans program as a template.	City-wide	FY16	Ongoing	T&SW
CSD-29	Conduct special studies.	Special studies will be conducted to gather data to identify pollutant sources, appropriate targets, or other information. Includes collaboration with universities.	City-wide	FY16	Ongoing	T&SW
CSD-29.1	Participate in Reference Watershed Study.	The San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from streams in a minimally disturbed or “reference” condition. Refer to Section 5.1 for further details.	Region-wide	Prior to FY16	One time	T&SW, SCCWRP, Regional copermittees

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-29.2	Participate in Reference Beach Study.	The San Diego Regional Reference Beach Study will develop numeric targets that account for "natural sources" to establish the concentrations or loads from the beach in a minimally disturbed or "reference" condition. The purpose of this monitoring program is to advise the public of potential health risks that could occur with water contact recreation at local beaches. DEH will post a health advisory notice or close a beach when FIB results are above REC-1 water quality standards.	Region-wide (San Dieguito)	Prior to FY16	One time	T&SW, SCCWRP, Regional copermittees
CSD-29.3	San Dieguito Source Identification and Prioritization Process	Assess sources of bacteria in the watersheds using the San Diego Bacteria Source Identification and Prioritization Process developed in 2012 as part of the MS4 Permit Report of Waste Discharge process. Focus is on the beach/lagoon area of the San Dieguito River WMA, with inputs from the upper watershed also considered where relevant and necessary to identify sources of bacteria to the beach/lagoon. Refer to Section 5.1 for further details.	San Dieguito River WMA	FY16	One time	T&SW
CSD-29.4	Collaborate with City of San Diego PUD and other watershed stakeholders in the Lake Hodges Water Quality Concentration Study. Study will characterize conditions and identify sources.	The City of San Diego's Public Utilities Department will conduct studies that can characterize the nutrient budget or "loading rate" for Lake Hodges. The proper characterization of nutrient loads to Lake Hodges include two components: (1) Uninterrupted sampling during storm events or high water flow to Lake Hodges; and (2) Independent characterizations of nitrogen and phosphorus loads to the reservoir. This strategy will include collaboration with other watershed stakeholders.	San Dieguito River WMA	FY17	2 yrs.	T&SW with PUD; Funding from Prop 50, Prop 80, etc. Other San Dieguito River WMA Responsible Agencies
CSD-29.5	Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit.	Using the adaptive management process outlined in Section 6, remove 303(d) delisted beach segments from the Bacteria TMDL and Attachment E of the MS4 Permit.	San Dieguito River WMA	FY16	Ongoing	T&SW, Potential Stakeholders, Coastkeeper
CSD-29.6	Conduct a Cost of Service Study.	Conduct a Cost of Service Study that will examine the full cost of flood control and storm water strategies needed to comply with storm water regulations for the City of San Diego. The City of San Diego's Watershed Asset Management Plan will be used as the basis for the study.	City-wide	FY16	One time	TBD
CSD-30	Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	SROI is an economics-based framework for evaluating quantitative and qualitative performance metrics and monetizing them, if possible, along a triple bottom line (i.e. financial, societal, and environmental). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW and public participation

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-31	Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for individuals experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	Support a non-profit or consortium to provide sanitation services associated with hygiene as well as trash management for persons experiencing homelessness. Rented or purchased shower/sanitary trailers providing mobile showers may be organized at specifically scheduled locations and times. This provision has been proposed as a method for preventing surface water usage for sanitation and bathing, as well as opportunity for outreach and referral by social service agencies. The trash management services will include providing trash bags, trash collection areas, and shower/sanitary facilities at centers which provide daytime shelter to their clients, or on a mobile-basis for known transit camps. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW
CSD-32	Identify strategy, resources, and funding to support mapping and assessment of agricultural operations.	Prepare and maintain an inventory of the locations of agricultural operations. Identify agricultural land close to receiving waters and/or MS4 system and conducting a site reconnaissance to assess if discharges are likely to occur and develop a series of follow-up actions specific to those risks. Coordinate with other City of San Diego departments that own and lease land for agricultural uses. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito above Lake Hodges	Optional	TBD	PUD with T&SW
CSD-33	Coordinate with County of San Diego and identify resources and funding to implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	Coordinate with County of San Diego program. The extent, age, and location of on-site systems are generally not well documented. Recommended first step is to inventory and map all of the on-site systems. Techniques involve cross-referencing addresses for customers of central sewer provides with addresses of properties on the associated tax assessor's list, and identifying those addresses without a sewer account. Once on-site systems have been identified, the following parameters can be estimated or analyzed for risk assessment: location on the property, system age (from permit or property tax records), soil and slope conditions, development densities, and proximity to surface and groundwater resources. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito River WMA	Optional	TBD	T&SW with County of San Diego

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-34	Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals, where feasible.	Perform a feasibility study to determine if implementing an UTC program would be beneficial to the City's goals. UTC intercepts rainfall through increased coverage of leaves, branches, and stems and reduces runoff from the storm drainage system. Benefits associated with enhancing an UTC include reducing heat island effects and air pollution in addition to aesthetics and community benefits. Where feasible, native trees will be utilized to prevent invasive trees from migrating to open spaces and to conserve water. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	City-wide	Optional	TBD	Planning Dept. with T&SW, SANDAG, and Nature Conservancy
CSD-35	Conduct a feasibility study to test Permeable Friction Course (PFC), a porous asphalt that overlays impermeable asphalt.	Perform an assessment to determine the feasibility of implementing PFC on City streets. PFC, an overlay of porous asphalt, is an innovative roadway material that improves driving conditions in wet weather and water quality. Placed in a layer 25-50mm thick on top of regular impermeable pavement, PFC allows rainfall to drain within the porous layer rather than on top of the pavement. PFC has also been shown to reduce concentrations of pollutants commonly observed in highway runoff. PFC incorporates stormwater treatment into the roadway surface and does not require additional right-of-way. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	City-wide	Optional	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-36	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	This strategy may be implemented if there is interest in participation by the public or private entity with current control of the land. Conditions to be met also include 1) identification of partners, if needed (public, private, non-profit), 2) identification of costs and potential sources of funding, 3) final agreement by public or private entity with current control of the land, 4) final agreement by all other participating partners including acceptance by intended land- or asset-owning City department, 5) funding in place, and 6) if it can be determined that the benefit of preventing increased pollutant loads and minimizing impacts of future growth through land conservation is a more cost effective strategy to meet interim and final numeric goals than other recommended strategies included in this plan (Chesapeake Bay Commission, 2013).	City-wide	Optional	TBD	TBD
CSD-37	Lake Hodges Natural Treatment System Project	Coordinate with watershed stakeholders on Integrated Regional Water Management (IRWM) Proposition 84 funding grant project to model the Lake Hodges watershed (hydrology and water quality loading) to assist in siting locations for nutrient reducing BMPs. Recommendations include using the 85th percentile event for sizing multiuse treatment area BMPs, locating and defining baseflow within key reaches.	San Dieguito River WMA (Lake Hodges)	Optional	TBD	T&SW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-38	Participate in a watershed council or group if one is established.	This strategy may be triggered as 1) partners have been identified and formal MOUs have been developed and 2) consensus and community support has been achieved.	City-wide	Optional	TBD	TBD
CSD-39	Prohibit introduction of invasive plants in new development and redevelopment projects.	Coordinate with the City's Development Services Department to continue to prohibit introduction of invasive species such as Arundo donax and Cortaderia selloana for new development or redevelopment projects as specified in the City's municipal code for landscape.	City-wide	Prior to FY16	Ongoing	T&SW with DSD
CSD-40	Collaborate with stakeholders and water agencies in ongoing efforts to address water quality issues in the San Dieguito Watershed as they pertain to MS4 discharges.	Includes participation in Integrated Regional Water Management-led efforts such as coordination and review of grant proposals, research, analysis, studies, modeling.	San Dieguito River WMA	Prior to FY16	Ongoing	T&SW with DSD
Green Infrastructure						
CSD-41	Del Mar Heights Rd Median (Project ID 1018)	A grassed/vegetated swale or grassed/vegetated strip has been proposed for the Del Mar Heights Road median about 350 feet west of the Del Mar Heights and Carmel Valley Road intersection to treat a 0.8-acre drainage area	San Dieguito River WMA (Del Mar Heights Rd and Carmel Valley Rd)	Prior to FY16	Ongoing	T&SW with PWD
CSD-42	If interim load reduction goals are not met and additional green infrastructure is required, additional publicly-owned parcels have been identified as potential opportunities for green infrastructure implementation.	Construction, operation, and maintenance of bioretention and permeable pavement. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	Prioritized public parcels in San Dieguito WMA	Optional	TBD	T&SW with PWD; Potential to collaborate with transit agencies, public school districts, and state and federal agencies
Green Streets						
CSD-43	Callado Road	Construction, operation and maintenance of a green street project at Callado Road and Pastoral Street to treat a 9.86-acre drainage area.	San Dieguito River WMA (Callado Rd and Pastoral St)	FY16	FY18	T&SW with PWD
CSD-44	If interim load reduction goals are not met and additional green infrastructure is required, the additional acreage of bioretention and permeable pavement may be implemented through green streets if potential opportunities for green infrastructure implementation on public parcels are not available.	This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito River WMA	Optional	TBD	T&SW with PWD
Multiuse Treatment Areas						
Infiltration and Detention Basins						
CSD-45	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin may be implemented on open space across from San Pasqual Union Elementary School can be implemented upon detailed site assessment.	Construction, operation and maintenance of an Infiltration basin that would treat approximately 5,818 acres of drainage area on 19 acres of available space (APN 2410601100). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito River WMA (Rockwood Rd and Public Rd)	Optional	TBD	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-46	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin may be implemented on open space between I-15 and West Bernardo Drive.	Construction, operation and maintenance of an infiltration basin that would treat approximately 146 acres of drainage area on 6.0 acres of available space. The site is centrally located in the San Dieguito WMA, between I-15 and West Bernardo Drive (south of the Ed Brown Center). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito River WMA (Between I15 and West Bernardo Dr., south of Ed Brown Center)	Optional	TBD	T&SW with PWD
CSD-47	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin(s) may be considered on publicly owned open spaces in canyon areas on a case-by-case basis when no other opportunities for load reductions exist.	Construction, operation, and maintenance of infiltration basin(s) in canyon areas. 9 potential canyon sites, owned by the City of San Diego or CSD Open Space Parks, have been identified in San Dieguito WMA that provide up to 1,406 acres of available space (1,885 total parcel acreage). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	San Dieguito River WMA	Optional	TBD	T&SW with PWD
Stream, Channel and Habitat Rehabilitation Projects						
CSD-48	If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.	This strategy may be triggered as 1) funding to address MS4 discharges is identified and secured, 2) staff resources are identified and secured, 3) partners have been identified and formal MOUs have been developed, 4) permits required by regulatory agencies are secured, 5) recommendations from the community are identified and consensus and community support has been achieved, and 6) it can be determined that the benefit of preventing increased pollutant loads and minimizing impacts of future growth through land conservation is a more cost effective strategy to meet interim and final numeric goals than other recommended strategies included in this plan (Chesapeake Bay Commission, 2013).	Areas identified during feasibility studies	Optional	TBD	T&SW
Water Quality Improvement BMPs						
Proprietary BMPs						
CSD-49	Black Mountain Ranch - Northern Areas, Project ID 1386	Existing project - constructed BMPs include 4 drainage inserts, 2 filtration systems and 10 hydrodynamic separation systems.	San Dieguito River WMA (Black Mountain Ranch)	Prior to FY16	Ongoing	T&SW with PWD
CSD-50	Black Mtn. Ranch Community Park (discretionary) - Project ID 1006	A hydrodynamic separation system and 3 drainage inserts were installed at Black Mountain Ranch Community Park under the west corner of the property, behind the baseball fields and near an existing concrete swale.	San Dieguito River WMA (Black Mountain Ranch Community Park)	Prior to FY16	Ongoing	T&SW with PWD
CSD-51	Camino Del Sur and Maranatha Dr. - Project ID 139	A hydrodynamic separation system was installed along the north side of Camino Del Sur, just west of Maranatha Drive.	San Dieguito River WMA (North side of Camino Del Sur, west of Maranatha Dr.)	Prior to FY16	Ongoing	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-52	Fire Station #46 Santaluz - Project ID 991	Installed 4 drainage inserts at Fire Station #46 near the entrance of parking lot off of Lazanja Drive.	San Dieguito River WMA (Fire Station #46)	Prior to FY16	Ongoing	T&SW with PWD
CSD-53	Rancho Bernardo Community Park Dog Off-Leash Area - Project ID 865	A drainage insert was installed at Rancho Bernardo Community Park near the Dog Off-Leash Area.	San Dieguito River WMA (Rancho Bernardo Community Park)	Prior to FY16	Ongoing	T&SW with PWD
Dry Weather Flow Separation and Treatment Projects						
CSD-54	If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.	Construction of dry weather flow separation and treatment projects, where identified. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, and 4) permits required by regulatory agencies are secured.	Downstream reaches where persistent dry weather flows have been observed	Optional	TBD	T&SW with PWD
Trash Segregation						
CSD-55	If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.	Construction of trash segregation (Trash Guards, etc.) projects, where identified. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, and 4) permits required by regulatory agencies are secured.	High-loading areas city-wide	Optional	TBD	T&SW with PWD

Notes: DSD= Development Services Department; PUD = Public Utilities Department; PWD = Public Works Department; T&SW = Transportation and Storm Water Division; WAMP = Watershed Asset Management Plan; TBD = will be determined during the next fiscal year.

Reference: Chesapeake Bay Commission. 2013. *Crediting Conservation: Accounting for the Water Quality Value of Conserved Lands Under the Chesapeake Bay TMDL*. Available online at http://www.chesbay.us/Publications/CreditingConservationReport.pdf. June.

Table I-5 City of San Diego Annual Schedule

Legend
Construction
Ongoing Implementation/ O&M
As needed/Design

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32	FY 33	FY 34	FY 35
Jurisdictional Strategies																								
Development Planning																								
All Development Projects																								
CSD-1	Establish guidelines and standards for all development projects; provide technical support related to implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area or implement easements to protect water quality, where applicable and feasible. Includes internal coordination and collaboration between City departments (DSD, PWD, and Engineering) to improve success and long-term benefits of BMPs.	City-wide	Prior to FY16	Ongoing																				
CSD-1.1	Investigation and research of emerging technology.	City-wide	Prior to FY16	As Needed																				
CSD-1.2	Approve and implement a green infrastructure policy.	City-wide on public parcels	FY16 (Begin)	As Needed																				
CSD-1.3	Develop Design Standards for Public LID BMPs.	City-wide	FY14-FY15	As Needed																				
CSD-1.4	Outreach to impacted industry regarding minimum BMP requirement updates.	City-wide	FY15	As Needed																				
CSD-2	Train staff on LID regulatory changes and LID practices.	City-wide	FY16		As Needed																			
CSD-3	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities to support compliance with the MS4 Permit and TMDLs in a reasonable manner. Ensure consistency with the City of San Diego's BMP Design Manual. Update the Storm Water Standards Manual accordingly.	City-wide	FY15	As Needed																				
CSD-4	Create a manual that outlines right-of-way design standards.	City-wide	FY15	One time																				
CSD-5	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	City-wide	Prior to FY16	Ongoing																				
Priority Development Projects (PDPs)																								
CSD-6	For PDPs, provide technical support to other City departments to ensure implementation of on-site structural BMPs to control pollutants and manage hydromodification by developing City wide storm water development standards and design guidelines.	City-wide	FY16		Ongoing																			
CSD-6.1	Institute a program to verify and enforce maintenance and performance of treatment control BMPs.	City-wide	FY16		Ongoing																			
CSD-7	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	City-wide	FY15	Cycle																				

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-7.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.	City-wide	FY15	One time																				
CSD-7.2	Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.	City-wide	FY15	One time																				
CSD-7.3	Amend BMP Design Manual for nurseries and garden centers.	City-wide	FY15	One time																				
CSD-7.4	Amend BMP Design Manual for auto-related uses.	City-wide	FY15	One time																				
CSD-8	Develop and administer an alternative compliance program for on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5.	City-wide	FY15	Ongoing																				
CSD-8.1	Create a fund that allows habitat acquisition, protection enhancement, and restoration in conjunction with other cooperating entities including community groups, academic institutions, state county, and federal agencies, etc.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
Construction Management																								
CSD-9	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing temporary BMPs that control sediment and other pollutants during the construction phase of projects. Included in that understanding are requirements to inspect at appropriate frequencies and effectively enforce requirements through process controlled by other City departments.	City-wide	FY16		Ongoing																			
Existing Development																								
Commercial, Industrial, Municipal, and Residential Facilities and Areas																								
CSD-10	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	City-wide	FY16		Ongoing																			
CSD-10.1	Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include required street sweeping, catch basin cleaning, and maintenance of private roads and parking lots in targeted areas.	City-wide	FY15	Cycle																				
CSD-10.2	Outreach to property managers and trash haulers to elevate the emphasis of power washing as a pollutant source.	City-wide Residential, commercial and industrial areas	FY15	Ongoing																				
CSD-10.3	Implement property based inspections.	City-wide	Prior to FY16	Ongoing																				
CSD-10.4	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	City-wide	FY15	As Needed																				
CSD-11	Promote and encourage implementation of designated BMPs for residential and non-residential areas.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-11.1	Residential and Commercial BMP: Rain Barrel	City-wide Residential Areas	Prior to FY16	Ongoing																				
CSD-11.2	Residential and Commercial BMP: Grass Replacement	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				
CSD-11.3	Residential and Commercial BMP: Downspout Disconnect	City-wide Residential and Commercial Areas	FY16		Ongoing																			
CSD-11.4	Residential and Commercial BMP: Microirrigation	City-wide Residential Areas	Prior to FY16	Ongoing																				
CSD-11.5	Provide Onsite Water Conservation Surveys.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				
MS4 Infrastructure																								
CSD-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, channels as allowed by resource agencies, detention basins, etc.) for water quality improvement and for flood control risk management.	City-wide	FY16		Ongoing																			
CSD-12.1	Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.	City-wide	FY16		Ongoing																			
CSD-13	Coordinate with other City departments (PUD) to implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	City-wide	FY16		Ongoing																			
CSD-13.1	Identify sewer leaks and areas for sewer pipe replacement prioritization.	City-wide	FY16		As Needed																			
Roads, Street, and Parking Lots																								
CSD-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	City-wide	FY16		Ongoing																			
CSD-14.1	Initiate sweeping of medians on high-volume arterial roadways.	City-wide	FY17			Ongo ing																		
Pesticide, Herbicides, and Fertilizer BMP Program																								
CSD-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	City-wide	FY16		Ongoing																			
Retrofit and Rehabilitation in Areas of Existing Development																								
CSD-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	City-wide	TBD																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32	FY 33	FY 34	FY 35
CSD-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	City-wide	TBD																					
Illicit Discharge, Detection, and Elimination (IDDE) Program																								
CSD-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	City-wide	Prior to FY16	Ongoing																				
Public Education and Participation																								
CSD-19	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	City-wide	Prior to FY16	Ongoing																				
CSD-19.1	Continue implementation of a Pet Waste Program.	City-wide	Prior to FY16	Ongoing																				
CSD-19.2	Promote and encourage implementation of designated BMPs in commercial and industrial areas.	City-wide Non-residential Areas	Prior to FY16	Ongoing																				
CSD-19.3	Expand outreach to homeowners' association (HOA) common lands and HOA incentives.	City-wide	FY16		Ongoing																			
CSD-19.4	Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.	City-wide	FY16		Ongoing																			
CSD-19.5	Enhance and expand trash cleanups through community-based organizations involving target audiences.	City-wide	FY16		Ongoing																			
CSD-19.6	Improve consistency and content of websites to highlight enforceable conditions and reporting methods.	City-wide	Prior to FY16	Ongoing																				
CSD-19.7	Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.	San Dieguito River WMA	FY16		Ongoing																			
CSD-19.8	Enhance school and recreation-based education and outreach.	City-wide	FY15	Ongoing																				
CSD-19.9	Develop education and outreach to reduce irrigation runoff.	City-wide	Prior to FY16	Ongoing																				
CSD-19.10	Develop regional training for water-using mobile businesses.	City-wide	FY16		Ongoing																			
CSD-19.11	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	City-wide	FY16		Ongoing																			
CSD-19.12	Continue to promote and encourage implementation of Integrated Pest Management (IPM) for residents and businesses.	City-wide	Prior to FY16	Ongoing																				
Enforcement Response Plan																								
CSD-20	Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Storm Water Code Enforcement Unit's Standard Operating Procedures (SOPs) - Enforcement Response Plan.	City-wide	Prior to FY16	Ongoing																				
CSD-20.1	Increase enforcement of irrigation runoff.	City-wide	FY16		Ongoing																			
CSD-20.2	Increase enforcement of water-using mobile businesses.	City-wide	FY16		Ongoing																			

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-21	Increase enforcement of all minimum BMPs for existing residential, commercial, and industrial development.	City-wide	FY16		As needed																			
CSD-22	Increase enforcement associated with property-based inspections.	City-wide	FY16		Ongoing																			
CSD-23	Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.	City-wide	FY16		Ongoing																			
CSD-24	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	City-wide	FY16		Ongoing																			
Additional Nonstructural Strategies																								
CSD-25	Conduct a Comprehensive Benefits Analysis to identify benefits other than water quality that are applicable to each of the specific WQIP strategies.	City-wide	FY15	One time																				
CSD-26	Address and clean up trash from transient encampments with collaboration from the Homeless Outreach Team.	City-wide	FY16		Ongoing																			
CSD-27	Continue participating in source reduction initiatives.	City-wide	Prior to FY16	Ongoing																				
CSD-27.1	Coordinate with Fleet Services to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available.	City-wide	FY18				Ongoing																	
CSD-28	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	City-wide	FY16		Ongoing																			
CSD-29	Conduct special studies.	City-wide	FY16		Ongoing																			
CSD-29.1	Participate in Reference Watershed Study.	Region-wide	Prior to FY16	One time																				
CSD-29.2	Participate in Reference Beach Study.	Region-wide (San Dieguito)	Prior to FY16	One time																				
CSD-29.3	San Dieguito Source Identification and Prioritization Process	San Dieguito River WMA	FY16		One time																			
CSD-29.4	Collaborate with City of San Diego PUD and other watershed stakeholders in the Lake Hodges Water Quality Concentration Study. Study will characterize conditions and identify sources.	San Dieguito River WMA	FY17			Ongoing																		
CSD-29.5	Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit.	San Dieguito River WMA	FY16		Ongoing																			
CSD-29.6	Conduct a Cost of Service Study.	City-wide	FY16		One time																			
CSD-30	Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-31	Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for individuals experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-32	Identify strategy, resources, and funding to support mapping and assessment of agricultural operations.	San Dieguito above Lake Hodges	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-33	Coordinate with County of San Diego and identify resources and funding to implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	San Dieguito River WMA	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-34	Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals, where feasible.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-35	Conduct a feasibility study to test Permeable Friction Course (PFC), a porous asphalt that overlays impermeable asphalt.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-36	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-37	Lake Hodges Natural Treatment System Project	San Dieguito River WMA (Lake Hodges)	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-38	Participate in a watershed council or group if one is established.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-39	Prohibit introduction of invasive plants in new development and redevelopment projects.	City-wide	Prior to FY16	Ongoing																				
CSD-40	Collaborate with stakeholders and water agencies in ongoing efforts to address water quality issues in the San Dieguito Watershed as they pertain to MS4 discharges.	San Dieguito River WMA	Prior to FY16	Ongoing																				
Green Infrastructure																								
CSD-41	Del Mar Heights Rd Median (Project ID 1018)	San Dieguito River WMA (Del Mar Heights Rd and Carmel Valley Rd)	Prior to FY16																					
CSD-42	If interim load reduction goals are not met and additional green infrastructure is required, additional publicly-owned parcels have been identified as potential opportunities for green infrastructure implementation.	Prioritized public parcels in San Dieguito WMA	Optional												If triggered, begin planning, acquiring funding and resources									
Green Streets																								
CSD-43	Callado Road	San Dieguito River WMA (Callado Rd and Pastoral St)	FY16																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32	FY 33	FY 34	FY 35
CSD-44	If interim load reduction goals are not met and additional green infrastructure is required, the additional acreage of bioretention and permeable pavement may be implemented through green streets if potential opportunities for green infrastructure implementation on public parcels are not available.	San Dieguito River WMA	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to construct additional green streets projects.									
Multiuse Treatment Areas																								
Infiltration and Detention Basins																								
CSD-45	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin may be implemented on open space across from San Pasqual Union Elementary School can be implemented upon detailed site assessment.	San Dieguito River WMA (Rockwood Rd and Public Rd)	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-46	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin may be implemented on open space between I-15 and West Bernardo Drive.	San Dieguito River WMA (Between I15 and West Bernardo Dr., south of Ed Brown Center)	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-47	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin(s) may be considered on publicly owned open spaces in canyon areas on a case-by-case basis when no other opportunities for load reductions exist.	San Dieguito River WMA	Optional												If triggered, begin planning, acquiring funding and resources									
Stream, Channel and Habitat Rehabilitation Projects																								
CSD-48	If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.	Areas identified during feasibility studies	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement rehabilitation projects.									
Water Quality Improvement BMPs																								
Proprietary BMPs																								
CSD-49	Black Mountain Ranch - Northern Areas, Project ID 1386	San Dieguito River WMA (Black Mountain Ranch)	Prior to FY16																					
CSD-50	Black Mtn. Ranch Community Park (discretionary) - Project ID 1006	San Dieguito River WMA (Black Mountain Ranch Community Park)	Prior to FY16																					
CSD-51	Camino Del Sur and Maranatha Dr. - Project ID 139	San Dieguito River WMA (North side of Camino Del Sur, west of Maranatha Dr.)	Prior to FY16																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-52	Fire Station #46 Santaluz - Project ID 991	San Dieguito River WMA (Fire Station #46)	Prior to FY16																					
CSD-53	Rancho Bernardo Community Park Dog Off-Leash Area - Project ID 865	San Dieguito River WMA (Rancho Bernardo Community Park)	Prior to FY16																					
Dry Weather Flow Separation and Treatment Projects																								
CSD-54	If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.	Downstream reaches where persistent dry weather flows have been observed	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement dry weather flow separation projects.									
Trash Segregation																								
CSD-55	If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.	High-loading areas city-wide	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement trash segregation projects.									

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I.5 City of Solana Beach Strategies

The City of Solana Beach is a small coastal city with urban, dense development at the coastline and less dense residential lots and commercial centers to the east. Solana Beach, because of its small size, has inherent internal collaboration as staff implements multiple administrative programs, allowing oversight of planning, development, and enforcement on a holistic level. Similar to the other smaller jurisdictions, Solana Beach's jurisdictional strategies focus on implementing overarching programs, such as promoting BMPs in residential areas and collaborating with other departments and agencies to implement strategies. The City of Solana Beach has identified the jurisdictional strategies in Table I-6 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Table I-6
City of Solana Beach Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
SB-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-2	Municipal code and ordinances will be amended as necessary to encourage LID opportunities.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-3	Development Planning staff will review LID regulatory changes and ensure compliance with BMP Design Manual.	The City, due to its small size, has one staff member overseeing implementation of the development planning MS4 Permit requirements and ensures compliance with new requirements.	City-wide	FY16	As needed or required by permit	PWD/Engineering
SB-4	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and WQIP requirements.	At the initial plan review, a Stormwater Checklist is provided which lists the minimum standards required. One-on-one education is available at that time and throughout the development planning process.	City-wide	FY16	Ongoing	PWD/Engineering
Priority Development Projects (PDPs)						
SB-5	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-6	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP. County BMP Design Manual will be used and adapted for the City.	City-wide	FY16	As needed or required by permit	PWD/Engineering
SB-7	Expanded requirement for on-site treatment if impervious area is planned to increase by more than 500 square feet, a detention basin is required.	With increased impervious area of greater than 500 sq. ft., the City requires a detention basin to treat stormwater runoff. An agreement to maintain the detention basin is also required. This encourages LID and the protection of open space.	City-wide	Prior to FY16	Ongoing	PWD/Engineering
SB-8	Institute a program to verify and enforce maintenance and performance of treatment control BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
Construction Management						
SB-9	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP. BMPs are inspected once a month and before known rain events. Inventory is updated weekly.	City-wide	FY16	Ongoing	PWD/Engineering
SB-10	Maintain and update a watershed-based inventory of all construction projects issued a local permit that allows ground disturbance or soil disturbing activities.	Create a watershed-based inventory to track all construction projects issued a permit that allow ground disturbance or soil disturbing activities. Track the frequency and results of inspections.	City-wide	FY16	Ongoing	PWD/Engineering

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
SB-11	Implement or require implementation of BMPs that are site specific, seasonally appropriate and construction phase appropriate. Includes inspections at an appropriate frequency and enforcement of requirements.	Ensure that erosion control plans and BMP plans are appropriately designed at the permit and plan review phase. Perform and document BMP inspections per the Permit.	City-wide	FY16	Ongoing	PWD/Engineering
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
SB-12	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP. All existing commercial and industrial facilities are inspected annually. All existing municipal facilities are inspected monthly.	City-wide	FY16	Ongoing	PWD/Engineering
SB-12.1	Inspection all commercial and industrial facilities annually.	All commercial and industrial facilities are inspected annually.	City-wide	FY16	Ongoing	PWD/Engineering
SB-12.2	Require minimum BMPs for mobile businesses.	Water-using mobile businesses require minimum BMPs including recovery and removal of waste water.	City-wide	FY16	Ongoing	PWD/Engineering
SB-12.3	Review policies and procedures to ensure discharges from swimming pools are meeting current permit requirements.		City-wide	FY16	Ongoing	PWD/Engineering
SB-13	Implement pet waste program. May include installation and maintenance of pet waste bag dispensers and trash bins, signage and education, physical removal of pet waste, and enforcement.	Implement education and prevention program. Pet waste bag dispensers and trash bins provided in public areas.	City-wide	Prior to FY16	Ongoing	PWD/Engineering
SB-14	Promote and encourage implementation of designated BMPs at residential areas.	Collaborate with Santa Fe Irrigation District (SFID) to promote runoff reduction products and services and provide education to residential customers. Includes residential landscape evaluations and links to MWD and SDCWA rebates and incentives including weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing	PWD/Engineering with SFID
SB-15	Promote and encourage implementation of designated BMPs in commercial areas.	Collaborate with SFID to promote MWD's SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal to commercial facilities.	City-wide	FY16	Ongoing	PWD/Engineering with SFID
MS4 Infrastructure						
SB-16	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-16.1	Perform catch basin inspection and cleaning.	All catch basins inspected annually. Catch basins with excess trash and debris are cleaned annually.	City-wide	FY16	Ongoing	PWD/Engineering
SB-16.2	Inspect open-channels and repair scour ponds to reduce pollutant loads and invasive plants and animals as needed.	San Dieguito Creek channel is inspected annually. Maintenance is conducted as-needed.	City-wide	Prior to FY16	Ongoing	PWD/Engineering
SB-16.3	Repair and replace MS4 components to provide source control from MS4 infrastructure.		City-wide	Prior to FY16	Ongoing	PWD/Engineering

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
SB-17	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers and identify sewer leaks and areas for sewer pipe replacement.	The City will continue to implement an aggressive sewer infrastructure replacement program. The City CCTVs a quarter of the sewer infrastructure each year. The results lead to a prioritized list of sewer line replacement projects. The City invests approximately $500,000 in sewer replacement projects per year.	City-wide	Prior to FY16	Ongoing	PWD/Engineering
Roads, Street, and Parking Lots						
SB-18	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	-	City-wide	FY16	Ongoing	PWD/Engineering
SB-18.1	Implement street sweeping on roads and in parking lots.	Refer to JRMP. High priority streets are swept twice per month. Medium priority streets, including all residential streets, are swept once per month. Low priority streets, including 12 parking lots, are cleaned once per month.	City-wide	FY16	Ongoing	PWD/Engineering
SB-18.2	Perform sweeping of medians on high-volume arterial roadways.	Refer to JRMP. Medians on Highway 101 and Lomas Santa Fe are swept once per month.	City-wide	FY16	Ongoing	PWD/Engineering
Pesticide, Herbicides, and Fertilizer BMP Program						
SB-19	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	City does not have authority over application of pesticides, but will implement BMPs. Industrial and commercial inspections cover requirement.	City-wide	FY16	Ongoing	PWD/Engineering
Retrofit and Rehabilitation in Areas of Existing Development						
SB-20	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-21	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
Illicit Discharge, Detection, and Elimination (IDDE) Program						
SB-22	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
Public Education and Participation						
SB-23	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-23.1	Expand outreach, training, and incentive programs to homeowners' associations (HOAs).	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-23.2	Develop outreach and training program for property managers responsible for HOAs and Maintenance Districts.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-23.3	Conduct trash cleanups through community-based organizations involving target audiences.	In partnership with I Love a Clean San Diego, host a site in Solana Beach during two beach clean-ups per year.	City-wide	FY16	Ongoing	PWD/Engineering with I Love a Clean San Diego

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
SB-23.4	Target school-based education and outreach.	Collaborate with Solana Center to present relevant watershed and storm water pollution prevention information to school groups once a year.	City-wide	FY16	Ongoing	PWD/Engineering with Solana Center
SB-23.5	Develop education and outreach to reduce over-irrigation.	Work with SFID to educate residents about reducing over irrigation. Municipal code will be modified to address over irrigation issues.	City-wide	FY16	Ongoing	PWD/Engineering with SFID
SB-23.6	Continue to support the Clean and Green Committee; a committee of local residents and business owners working to preserve Solana Beach's environment.	Encourage public participation by supporting the Clean and Green Committee. The Clean and Green Committee addresses issues pertaining to water quality, air quality, and climate change. The City Council has also formed a Council Ad-Hoc subcommittee on Environmental Sustainability to work closely with the Clean and Green committee and provide direction to City staff on sustainability programs.	City-wide	FY16	Ongoing	PWD/Engineering
SB-23.7	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences.	City-wide	FY16	Ongoing	PWD/Engineering with regional education and outreach campaigns
Enforcement Response Plan						
SB-24	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering
SB-24.1	Increase enforcement of over-irrigation. Enforcement of power-washing included here.	Refer to JRMP.	City-wide	FY16	Ongoing	PWD/Engineering with SFID
Additional Nonstructural Strategies						
SB-25	Continue to apply NPDES pollution management fee to residential and commercial waste and recycling to secure funding for implementation of water quality related programs.	To ensure continued implementation of water quality improvement efforts, the City has secured funding through a NPDES pollution management fee.	City-wide	FY16	Ongoing	PWD/Engineering
SB-26	Continue participating in source reduction initiatives.	The City was the first to ban non-reusable plastic bags within the region in 2012.	City-wide	Prior to FY16	Ongoing	PWD/Engineering
SB-27	Develop a program to address and capture trash and debris.	Continue to maintain catch basin inserts to collect trash and prevent from flowing into the MS4 and subsequently the receiving water. Two catch basin inserts are installed within the jurisdiction in the San Dieguito WMA.	City-wide	FY16	Ongoing	PWD
SB-28	Conduct special studies.	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from streams in a minimally disturbed or “reference” condition. Refer to Section 5.1 for further details.	City-wide	TBD	TBD	TBD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
SB-28.1	Reference watershed study.	Assess sources of bacteria in the watersheds using the San Diego Bacteria Source Identification and Prioritization Process developed in 2012 as part of the MS4 Permit Report of Waste Discharge process. Focus is on the beach/lagoon area of the San Dieguito River WMA, with inputs from the upper watershed also considered where relevant and necessary to identify sources of bacteria to the beach/lagoon. Refer to Section 5.1 for further details.	City-wide	FY16	TBD	PWD with regional copermittees
SB-29	If projects are unable to meet structural BMP design standards or hydromodification management criteria, administer an alternative compliance program for on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5 and Appendix M for further details.	The City may administer an alternative compliance program for development and redevelopment as necessary.	TBD	Optional	TBD	PWD/Engineering
SB-30	If a regional social services effort is established, support workgroup to provide sanitation and trash management for person experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	If a regional effort is established, participate in workgroup and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	TBD	Optional	TBD	PWD
SB-31	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and acquiring privately-owned undeveloped open areas.	Where feasible, avoid hardscape development and degradation in unpaved open space areas, create permanent open space protections to undeveloped city-owned land.	TBD	Optional	TBD	PWD
Green Infrastructure						
SB-32	Hwy 101 curb cuts	Curb cuts were installed along Hwy 101 in 2014 and will continue to be maintained.	City-wide	Prior to 2014	2014	PWD/Engineering
SB-33	If interim load reduction goals are not met and additional green infrastructure is required, 8.9 ac of available space have been identified as potential opportunities for green infrastructure implementation on public parcels	Construction, operation and maintenance of potential on-site treatment projects on public parcels. There is up to 8.9 acres of available space for on-site treatment implementation on public parcels (if needed).	TBD	Optional	TBD	PWD/Engineering
Green Streets						
SB-34	If interim load reduction goals are not met and additional green infrastructure is required, the additional acreage required can be implemented through green streets if potential opportunities for green infrastructure implementation on public parcels are not available.	Construction, operation and maintenance of green streets.	TBD	Optional	TBD	PWD/Engineering
Water Quality Improvement BMPs						
Proprietary BMPs						
SB-35	CDS treatment unit	Installation of a CDS treatment unit at the north end of N. Cedros in 2004. (CG-3064)	City-wide	2004	Ongoing	PWD
SB-36	CDS treatment unit	Installation of a CSD unit in Fletcher Cove Park in 2007. Drainage area is 2.5 acres. (PF-004)	City-wide	2007	Ongoing	PWD
SB-37	Biofilter	Installation of a biofilter at La Colonia Park in 2002. (CG-3069)	City-wide	2002	Ongoing	PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Dry Weather Flow Separation and Treatment Projects						
SB-38	Seascape Sur Outfall Storm Water Diversion Structure Project	Proposed Seascape Sur Outfall Storm Water Diversion Structure Project. Approximate drainage area is 40.5 acres. Plan to start construction September 2014. Funded by Proposition 84 IRWM grant. Estimated cost is between $79,000 and $105,000. (Latitude 32.985441 Longitude 117.273058). Partner agency is San Elijo Joint Powers Authority.	City-wide	2014	2015	PWD with San Elijo Joint Powers Authority

PWD = Public Works Department; MWD = Metropolitan Water District; SDCWA = San Diego County Water Authority; SFID = Santa Fe Irrigation District; TBD = will be determined during the next fiscal year.

I.6 County of San Diego Strategies

Open space, agriculture, and other low-density land uses cover much of the County of San Diego's jurisdiction within the San Dieguito River WMA. The jurisdictional strategies reflect this and were chosen because they are well suited for these types of land uses. The County of San Diego has identified the jurisdictional strategies in Table I-7 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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APPENDIX J

Strategy Selection

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APPENDIX J. STRATEGY SELECTION

Jurisdictional strategies were selected based on their ability to (a) effectively and efficiently eliminate non-storm water discharges to the municipal separate storm sewer system (MS4), (b) reduce pollutants in storm water discharges in the MS4 to the maximum extent practicable (MEP), and (c) achieve the interim and final numeric goals. Efficiency in pollutant reduction is based on identifying the known and suspected areas and sources likely contributing to the highest priority water quality condition and then targeting those sources. To assist in the geographical identification of sources, watershed modeling and geographical information system (GIS) tools were used to estimate the relative bacteria loading within the San Dieguito WMA, land ownership and availability of public land for implementation, and physical watershed characteristics (such as slope and soil types) for selection of best management practices (BMPs).

The MS4 Permit requires identifying known and suspected areas and sources that cause or contribute to the highest priority water quality condition within the following Responsible Agency inventories: MS4 outfalls, priority development projects, construction sites, and existing developments. Results of the analysis of relative wet and dry weather bacteria pollutant loadings may be used to meet this permit requirement by strategically focusing nonstructural programs and activities in these areas. The pollutant loading was also combined with other factors to determine potential locations for structural BMP implementation.

J.1 Bacteria Source Prioritization

To identify potential geographic areas where bacteria-generating activities are contributing to watershed pollutant loads, subwatersheds delineated in recent modeling were prioritized, based on the modeled bacteria loading results. The model estimated the bacteria loading, based on physical watershed characteristics (e.g. slope, soil types, and precipitation zones) and land-use-based runoff parameters, and was calibrated to measured receiving water results. The model used best available data at the time the model was created. The prioritization estimates the relative bacteria loading; as more data are gathered through implementation of the San Dieguito River WMA Water Quality Improvement Plan, the prioritized areas may change.

All modeled bacteria results were averaged for both wet weather and dry weather, and then quintiles were established for each subwatershed and assigned to each pollutant. The individual quintile scores (1–5) for *Enterococcus*, fecal coliform, and total coliform were averaged to create a dry composite bacteria score and a wet composite bacteria score (Table J-1). A score of “5” indicates a subwatershed pollutant loading in the top 20^{th} percentile (high pollutant loading), whereas a score of “1” indicates a subwatershed loading in the bottom 20^{th} percentile (low pollutant loading). The dry and wet composite scores are shown in Figure J-1 and Figure J-2, respectively.

Table J-1
Water Quality Prioritization

TMDL Pollutant	Dry Composite Score (1–5)*	Wet Composite Score (1–5)*	Composite Water Quality Score
Bacteria, Sediment	Bacteria $_{dry}$**	Bacteria $_{wet}$**	Dry Composite Score + Wet Composite Score

Note:
* The 1–5 score represents the area loading's quintile, as determined by the modeling results. A score of "5" indicates that the area loading was in the top 20 percentile, whereas a score of "1" indicates an area loading in the bottom 20 percentile. Quintiles were established for each watershed.
**Bacteria$_{dry/wet}$ is the average of the dry *Enterococci*, fecal coliform, and total coliform scores.
TMDL = total maximum daily load

In Figure J-1, areas that are expected to contribute the highest bacteria loading (and are therefore suspected to have more bacteria sources) are shaded darker; areas that are less likely to contribute to bacteria loads are lightly shaded. Subwatersheds with more development (the western part of the watershed) are expected to contribute more bacteria than less-developed open spaces. The model simulates bacteria loading based on land use. Sources identified in Section 3 of the Water Quality Improvement Plan are generally associated with land use types, but are not explicitly represented in this prioritization. For example, sources such as the episodic sanitary sewer overflows are not explicitly included in the model, however residential areas or areas with general development do have a higher bacteria load associated than undeveloped areas. This prioritization is meant as a guideline for identification of geographic areas within which to investigate sources. Each Responsible Agency may have additional information to inform its jurisdictional strategies.

Further analysis to determine the site suitability for structural strategies is discussed in Section J.2.

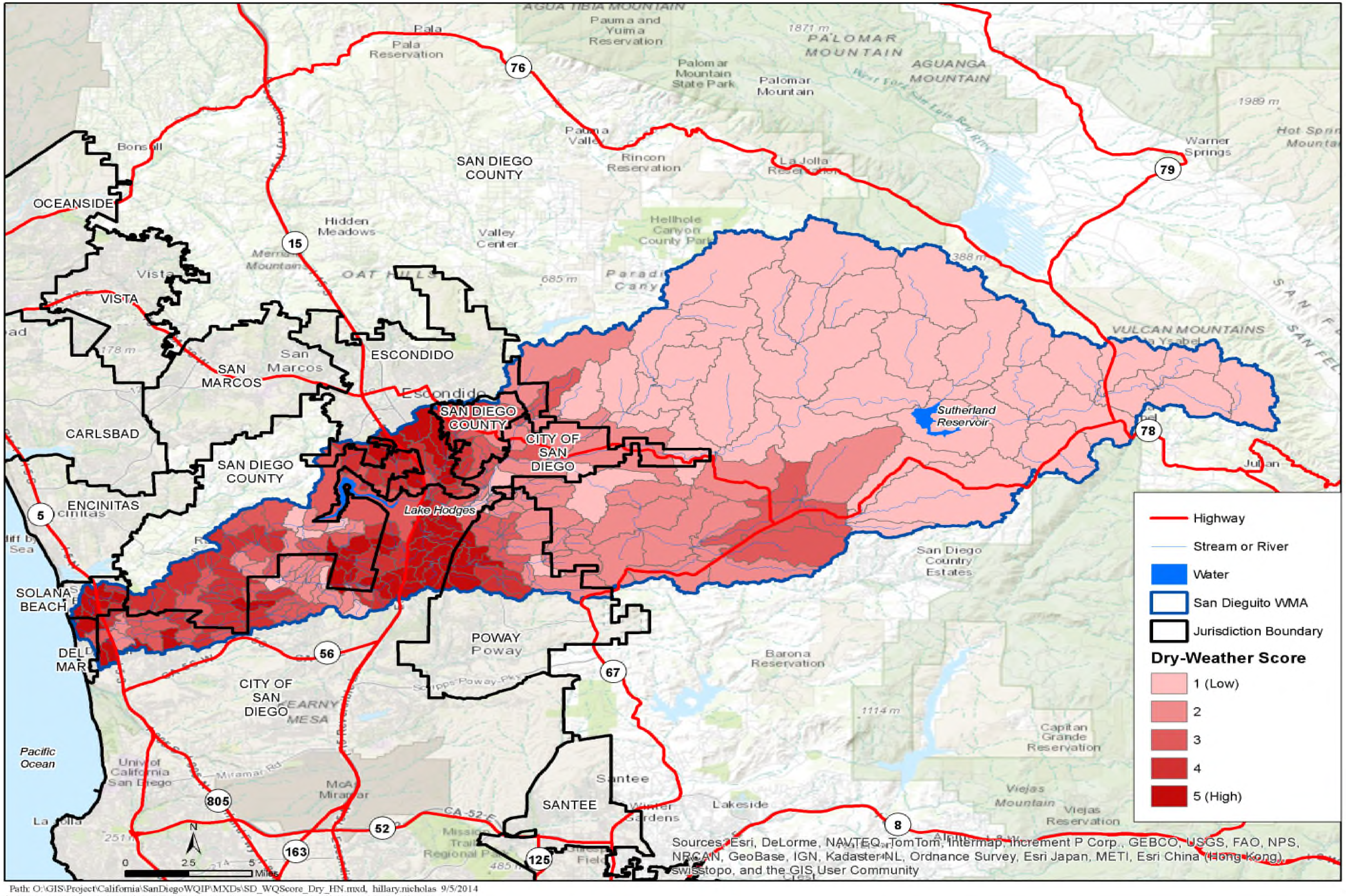
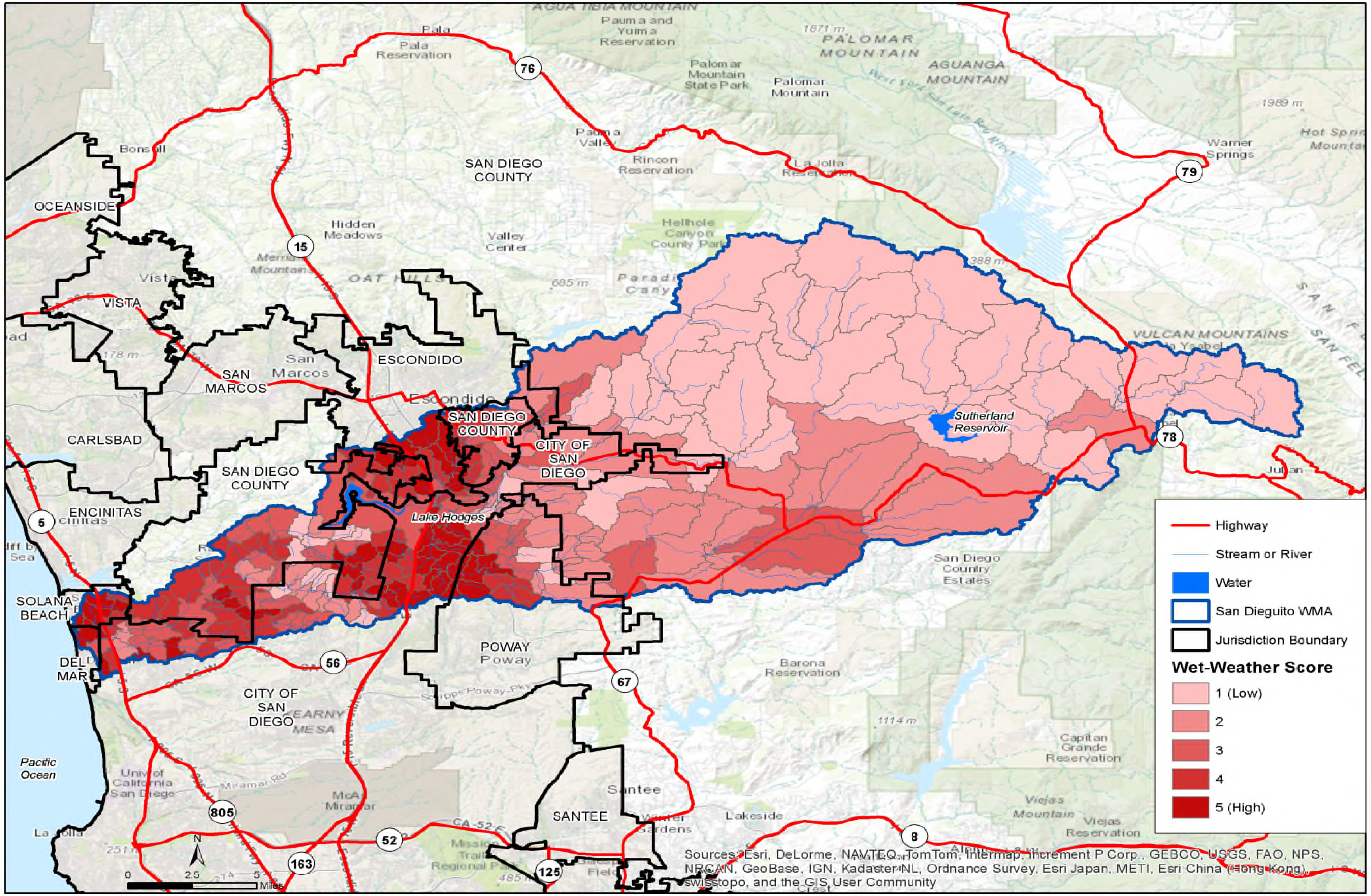


Figure J-1
Water Quality Composite Scores for Dry-Weather Bacteria



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Aerial Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Figure J-2
Water Quality Composite Scores for Wet-Weather Bacteria

J.2 Structural Strategy Site Identification

To identify suitable sites, structural strategies were developed using information regarding each Responsible Agency's existing, proposed, or planned structural BMPs that could contribute to future load reduction. Potential sites for construction of additional structural BMPs were also screened and prioritized, using the processes outlined below. This site identification process was completed for potential green infrastructure and multiuse treatment areas. Site suitability was not evaluated for water quality improvement BMPs because they were not the preferred structural solution for addressing wet weather flows at a watershed scale (i.e. water quality improvement BMPs do not tend to provide multiuse benefits to the community and typically treat smaller areas during wet weather flows than multiuse treatment areas and green infrastructure). Site selection was conducted in two phases, primary screening then prioritization.

J.2.1 Primary Screening

The primary screening process identified parcels potentially suitable for BMP implementation for both green infrastructure and multiuse treatment area BMPs. The primary screening process began with preliminary screening based on two parameters:

- ***Parcel Ownership and Zoning and Land Use:*** Land costs generally can be minimized by using existing public lands; therefore, all privately owned parcels were eliminated as potential BMP sites. All classifications of zoning and land use, and all indications of public ownership for public parcels were considered.
- ***Slope:*** Parcels with a slope greater than 15 percent were not considered for BMP opportunities. The screening was expanded to include areas in and around canyons for multiuse treatment area BMPs in order to maximize the potential treatment from canyon areas.

The results of the primary screening process provided a base list of parcels potentially suitable for BMP implementation. To further determine the suitability of each parcel, the base list of parcels was prioritized separately for green infrastructure and multiuse treatment areas, as described in the subsequent sections.

J.2.2 Green Infrastructure Prioritization Process

A geographic information system (GIS) was used to rank parcels by their relative suitability. To determine the optimal suitability, various criteria (such as pollutant loadings of the drainage areas) were considered, along with site parameters (such as soil infiltration rates). The characteristics used are presented below and the respective ranking criteria are listed in Table J-2. The results of the screening and prioritization process are shown in Figure J-3, in which areas that are most suitable for green infrastructure have the lightest green shading and areas that are least suitable have the darkest green shading.

- **Pollutant Loading:** Parcels where estimated pollutant loadings are greatest were given a higher priority. Land-based pollutant loadings were obtained from the CLRP Task 2 Pollutant Source Characterization modeling results. Pollutant loading percentiles were determined on a watershed basis, and represent the average pollutant loading scores. A composite wet- and dry-weather areal loading score was developed for each applicable TMDL pollutant in each watershed.
- **Parcel Zoning and Ownership:** Land costs generally are minimized by using existing public lands; therefore, a higher priority was placed on publicly-owned parcels.
- **Hydrologic Soil Groups:** The mapped hydrologic soils groups were used as an initial estimate of the infiltration rate and storage capacity of the soils. Sites where mapped hydrologic soils groups have infiltration rates suitable for infiltration BMPs received higher priority.
- **Wells, Water Supplies, and Contaminated Sites:** Areas near contaminated sites received lower priority because of their potential for increased costs and complications during implementation.
- **Environmentally Sensitive Areas:** Areas where runoff can be treated before draining to an ESA were given a higher priority.
- **Total Impervious Area:** Parcels with a larger total impervious area typically generate more runoff and greater pollutant loads, and so were given a higher priority. Where impervious data were not available, the impervious area was estimated using aerial imagery.
- **Percent Impervious:** Parcels with a higher percentage of impervious area also typically produce more runoff, and so were targeted on the basis of their greater potential to reduce volume and improve water quality.
- **Proximity to Existing BMPs:** To distribute treatment opportunities effectively throughout the watershed, areas close to existing or planned future BMPs were given a lower priority.
- **Proximity to Parks and Schools**: Areas closest to parks and schools were given a higher priority, in part to provide a greater opportunity for public outreach and education.
- **Proximity to the Storm Drainage Network:** Areas close to the storm drain network were given a higher priority. Green infrastructure BMPs on poorly draining soils require underdrain systems that tap into existing infrastructure, and siting these near the storm drain network can minimize cost.

Table J-2
Prioritization Criteria for Potential Green Infrastructure BMP Sites

Criterion	Score (1 = Worst; 5 = Best)				
	1	2	3	4	5
Wet weather areal pollutant loading (Table G-1)	<20th percentile	20–40th percentile	40–60th percentile	60–80th percentile	>80th percentile
Dry weather areal pollutant loading (Table G-1)	<20th percentile	40-20th percentile	60-40th percentile	80-60th percentile	>80th percentile
Parcel zoning, land use, and ownership	—	—	—	Other-owned public parcels (schools and universities, state and federal facilities, utilities, etc.) were given a priority score of 8.	City- or county-owned public parcels and rights-of-way were given a priority score of 10.
Hydrologic soil group (HSG)	D		C	—	A, B
Proximity to wells, water supplies, and contaminated soils (feet)	< 100	—	> 100	—	—
Proximity to environmentally sensitive area (ESA) (optional)	—	—	—	Drains to	Adjacent to
Impervious area (acres)	—	> 0.1	> 0.25	> 0.5	> 1
% imperviousness	< 50	—	—	80–90	60–80
Proximity of existing or proposed BMP site (miles)	< 2	2–3	3–4	4–5	> 5
Proximity to park or school (feet)	> 1,000		< 1,000	—	—
Proximity to storm drainage network (feet)	> 300	< 300	< 100	—	—

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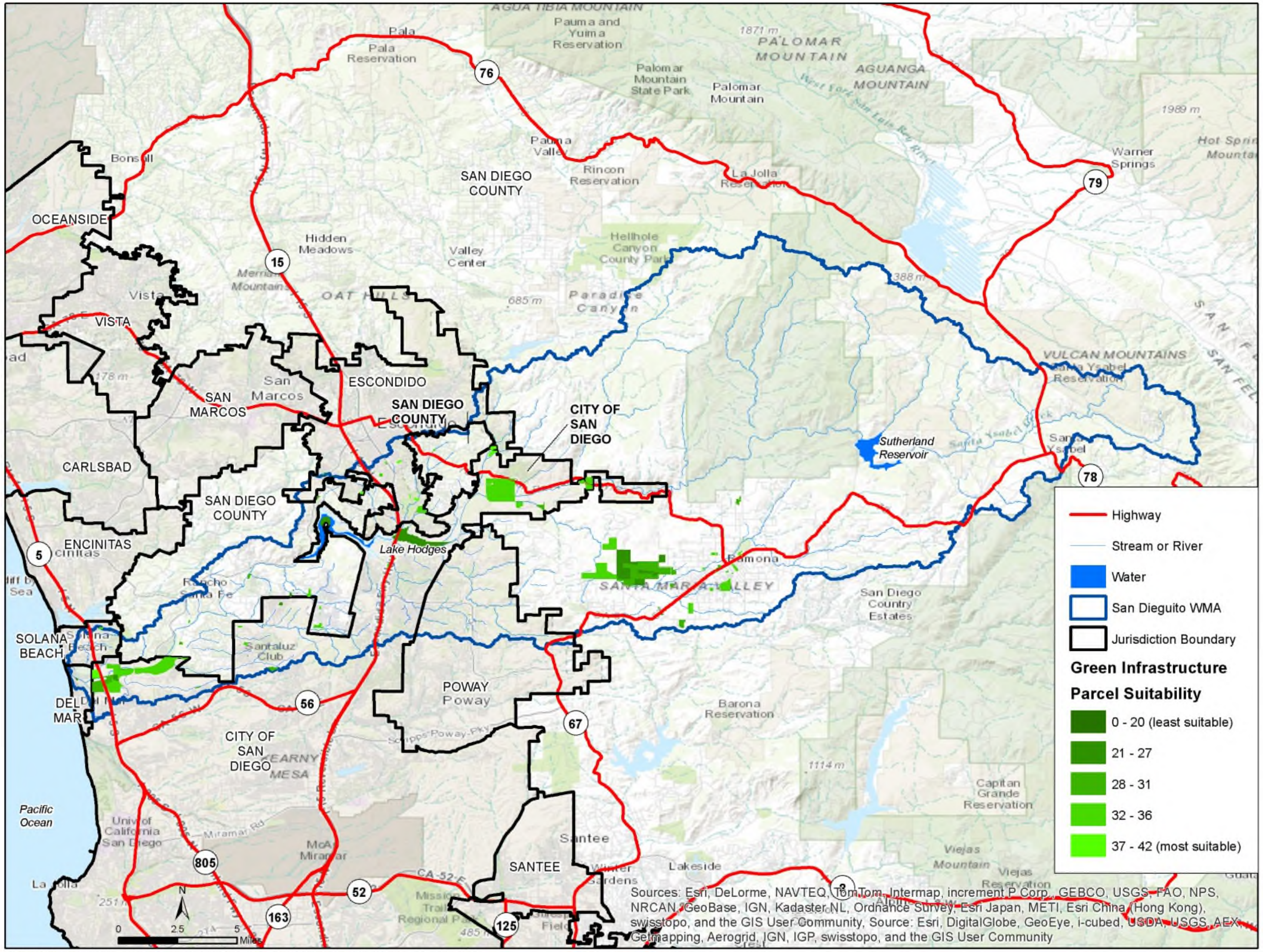

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Aerial Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Figure J-3
Green Infrastructure Parcel Suitability

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J.2.3 Multiuse Treatment Area Prioritization Process

Following the primary screening process, potential sites for multiuse treatment areas were evaluated and prioritized on the basis of (a) site characteristics that can affect BMP design or construction and (b) potential multiuse features, as presented in Table J-3. As with the primary screening, criteria were ranked with scores from 1 to 5, with “1” indicating low suitability and “5” indicating ideal conditions. Then the validity of the site was assessed, based on a review of aerial photography, to verify that the site visually meet the requirements of Table J-3. Next, potential multiuse treatment areas were subjected to a more detailed evaluation and site investigation. Implementation requirements were developed and assessed for each of these sites (including land acquisition requirements, permitting challenges, construction considerations, and preliminary cost estimates) and each site was ranked for implementation feasibility. Fact sheets summarizing each potential site were developed to guide future implementation.

The candidate multiuse treatment area BMP opportunities are denoted in Figure J-4.

Table J-3
Prioritization Criteria for Multiuse Treatment Area BMP Implementation

Criterion	Score (1 = Worst; 5 = Best)				
	1	2	3	4	5
Parcel type	—	—	—	Other-owned public parcels (schools/ universities, state and federal facilities, utilities, etc.) were assigned a priority score of 8.	City- or county-owned public parcels were assigned a priority score of 10.
Hydrologic soil group (HSG)	D	—	C	—	A, B
Proximity to wells and water supplies, and contaminated soils (feet)	< 100	—	> 100	—	—
Proximity to environmentally sensitive area (ESA)	—	—	—	Drains to	Adjacent to
% imperviousness	> 40%	—	—	30%–40%	≤ 30%
Parcel size (acres)	< 1	1–100	100–150	150–200	≥ 200
Proximity to existing or proposed best management practice (BMP) site (miles)	< 2	2–3	3–4	4–5	> 5
Proximity to park or school (feet)	> 1,000	—	< 1,000	School	Park
Proximity to storm drainage network (feet)	> 300	< 300	< 100	—	—
Contributing area (acres)	< 50	> 50	> 100	> 150	> 250
% imperviousness of contributing area	< 40	> 40	> 50	> 60	> 70
Proximity to corrugated metal pipe (CMP) systems (only in City of San Diego jurisdiction)	CMP requiring no action	—	CMP needing rehabilitation	—	CMP needing replacement

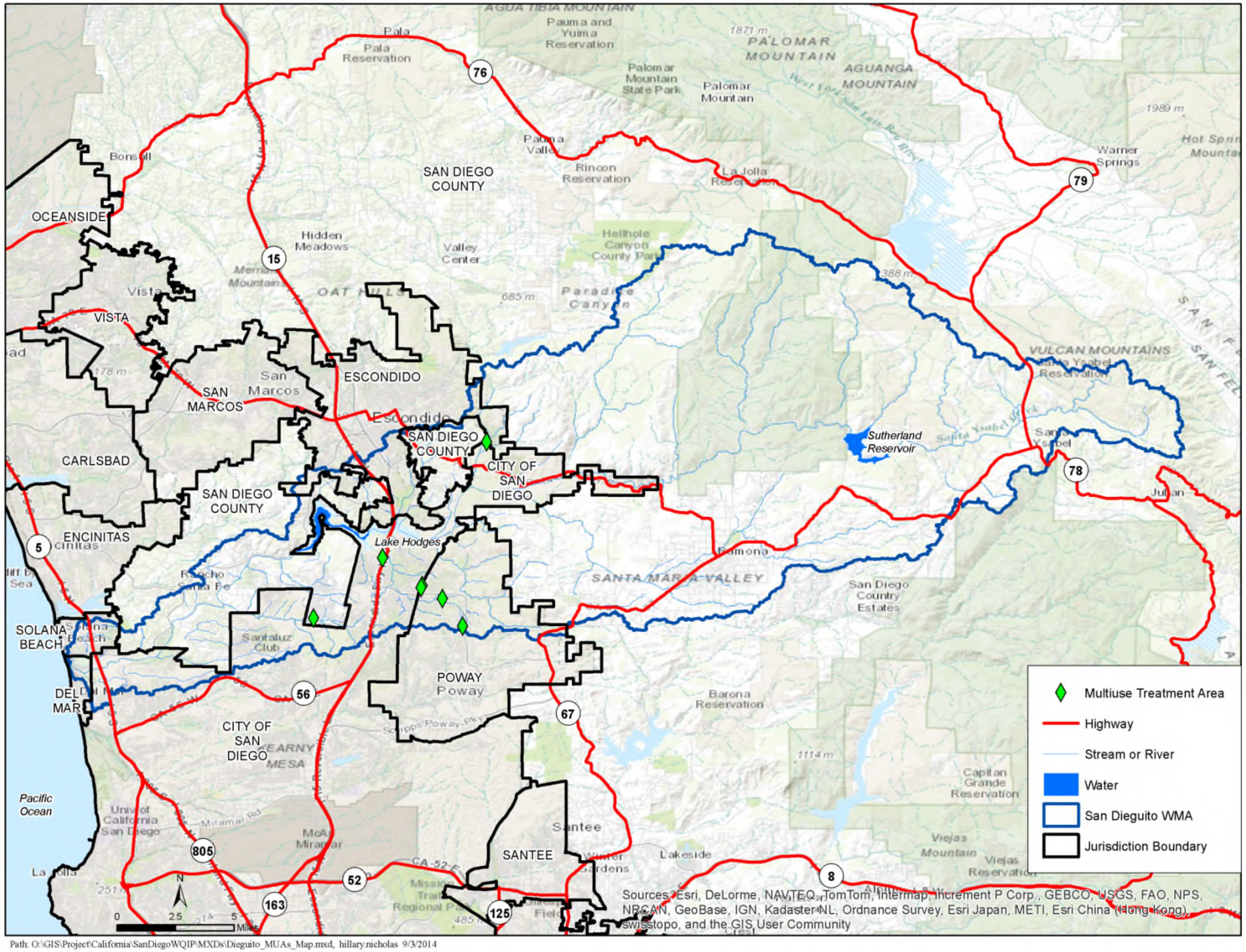

Figure J-4
Potential Sites for Multiuse Treatment Areas

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APPENDIX K

Strategy Benefits and References

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APPENDIX K. STRATEGY BENEFITS AND REFERENCES

The following references provide supporting documentation for the water chemistry, physical, and biological benefits associated with the strategy categories presented in the strategy benefit tables in Section 4.2.

K.1 Nonstructural Strategy References

Brown, E., D. Caraco, and R. Pitt. "Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments." USEPA X-82907801-0. Washington, D.C. October 2004.

California Stormwater Quality Association (CASQA). 2003a. *Municipal BMP Handbook*. Available online at https://www.casqa.org/resources/bmp-handbooks/municipal-bmp-handbook. January.

CASQA. 2003b. *New Development and Redevelopment Handbook*. Available online at https://www.casqa.org/sites/default/files/BMPHandbooks/BMP_NewDevRedev_Complete.pdf.

CASQA. 2011. *Construction BMP Online Handbook*. Available online at https://www.casqa.org/resources/bmp-handbooks/construction-bmp-online-handbook.

Center for Watershed Protection (CWP). 2006a. *Research in Support of an Interim Pollutant Removal Rate for Street Sweeping and Storm Drain Cleanout Activities, Technical Memorandum 1—Literature Review, Final Draft.* Center for Watershed Protection. October 2006.

CWP. 2006b. *Research in Support of an Interim Pollutant Removal Rate for Street Sweeping and Storm Drain Cleanout Activities, Technical Memorandum 2—Summary of Municipal Practices Survey*. Center for Watershed Protection. October 2006.

City of San Diego (City). 2008a. *City of San Diego Jurisdictional Urban Runoff Management Program*. January 2008.

City of San Diego. 2008b. *Storm Water Standards: A Manual for Construction and Permanent Storm Water Best Management Practices Requirements*. San Diego Municipal Code: Land Development Manual. City of San Diego.

County of San Diego. 2012. *County of San Diego SUSMP: Standard Urban Stormwater Mitigation Plan Requirements for Development Applications*. http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmppdf/susmp_manual_2012.pdf.

Duke, L.R. 1997. *Evaluation of Non-Storm Water Discharges to California Storm Drains and Potential Policies for Effective Prohibition*. Prepared for the California Regional Water Quality Control Board. Los Angeles, CA.

Grand River Inter-County Drainage Board (GRICDB). 2001. *Quantifying the Impact of Catch Basin and Street Sweeping on Storm Water Quality for a Great Lakes Tributary: A Pilot Study.* Prepared by Tetra Tech MPS with Pacific Water Resources, Inc. August 2001.

Irgang, L.M., K.Z. Atasi, J.E. Scholl, T. Biasell, W.S. Otwell, and J.D. Rooney. 2001. *Effects of Catch Basin Cleaning on Stormwater Quality: A BMP Demonstration Project*. Prepared for the Water Environment Federation. October 2001.

Lager, J.A., W.G. Smith, and G. Tchobanoglous. 1977. *Catchbasin Technology Overview and Assessment,* USEPA 60012-77-051. Cincinnati, OH. May 1977.

Mineart, P., and S. Singh. 2000. "The Value of More Frequent Cleanouts of Storm Drain Inlets." Technical Note #35 from *Watershed Protection Techniques,* 1(3):129-130.

National Environmental Education and Training Foundation (NEETF). 2005. *Environmental Literacy in America*.

Pitt, R. 2001. *Methods for Detection of Inappropriate Discharges to Storm Drainage Systems: Background Literature and Summary of Findings*. Prepared for Illicit Discharge Detection and Elimination (IDDE) Project Support Material, USEPA.

Pitt, R., et al. 1993. *A User's Guide for the Assessment of Non-Stormwater Dischargers Into Separate Storm Drainage Systems*, USEPA/600-R-92-238. Prepared for Risk Reduction Engineering Laboratory, USEPA. Cincinnati, OH.

Pitt, R. 1985. *Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning,* EPA/600/S2-85/038. Prepared for USEPA Water Engineering Research Laboratory. Cincinnati, OH. June.

San Diego Regional Water Quality Control Board (SDRWQCB). 2007b. *Waste Discharge Requirements for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, the San Diego Unified Port District, and the San Diego County Regional Airport Authority,* Order No. R9- 2007-0001. NPDES No. CAS0108758.

Taylor, A., and T.H.F. Wong (Taylor and Wong). 2002a. *Non-Structural Stormwater Quality Best Management Practices—An Overview of Their Use, Value, Cost and Evaluation*, Technical Report 02/11. Prepared for the Cooperative Research Centre for Catchment Hydrology, Monash University, Melbourne.

Taylor and Wong. 2002b. *Non-Structural Stormwater Quality Best Management Practices—A Survey Investigating Their Use and Value*, Technical Report 02/12. Prepared for the Cooperative Research Centre for Catchment Hydrology, Monash University, Melbourne.

Taylor and Wong. 2002c. *Non-Structural Stormwater Quality Best Management Practices—A Literature Review of Their Value and Life-Cycle Costs*, Technical Report 02/13. Prepared for the Cooperative Research Centre for Catchment Hydrology, Monash University, Melbourne. Accessed May 2, 2014, at http://www.clearwater.asn.au/user-data/ resource-files/CRC-Life-Cycle-Costing-2002.pdf>. Accessed May 02, 2014.

Tetra Tech, Inc. 2012. *Catch Basin Inlet Cleaning Pilot Study: Final Report*. Prepared for the City of San Diego.

Tetra Tech MPS. 2000. *Catch Basin Cleaning Study*. Prepared for the Rogue River Project and the City of Farmington Hills. September 2000.

U.S. Environmental Protection Agency (USEPA). 2014a. *Developing an Outreach Strategy*. Accessed May 1, 2014, at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=115.

USEPA. 2014b. *Public Education and Outreach on Stormwater Impacts.* Accessed May 1, 2014, at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=1.

USEPA. 2014c. *Compliance Assistance: Post-Inspection Compliance Assistance: General EPA Enforcement Process for Stormwater Violations at Construction Sites*. Accessed May 1, 2014, at http://www.epa.gov/compliance/assistance/postinspection/construction/enforcementsw.html

USEPA. 2000. *Stormwater Phase II Final Rule Fact Sheet 2.5: Illicit Discharge Detection and Elimination Minimum Measure,* EPA-833-F-00-007. USEPA Office of Water. Washington, DC. January 2000.

University of Kentucky, Kentucky Transportation Center. 2009. *Best Management Practices (BMPs) for Controlling Erosion, Sediment, and Pollutant Runoff from Construction Sites*. Accessed at http://www.kyt2.com/assets/files/uploads/09bmpmanual_final.pdf.

Weston Solutions (Weston). 2010a. *San Diego River Source Tracking Investigation—Phase II*. Prepared for the City of San Diego Storm Water Department. June 2010.

Weston. 2010b. *City of San Diego Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment*. Prepared for the City of San Diego Storm Water Department. June 2010.

K.2 Structural Strategy References

K.2.1 General

Barrett, M.E. 2008. "Comparison of BMP performance using the International BMP Database." *Journal of Irrigation and Drainage Engineering.* 134(5):556–561.

Bay Area Stormwater Management Agencies Association (BASMAA). 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection*. Accessed at http://www.basmaa.org/resources/files/Start%20at%20the%20Source%20%2D%20Design%20Guidance%20Manual%20for%20Stormwater%20Quality%20Protection%2E.pdf.

California Department of Transportation (Caltrans). 1995. *Standard Specifications*. Section 39, Hot Mix Asphalt.

California Stormwater Quality Association (CASQA). 2003. *California Stormwater BMP Handbook: New Development and Redevelopment.* Accessed at http://www.cabmphandbooks.com/documents/Development/DevelopmentHandbook.pdf.

Center for Watershed Protection (CWP). 2007. National Pollutant Removal Performance Database. Ellicott City, MD.

Fassman, E. 2012. "Stormwater BMP treatment performance variability for sediment and heavy metals." *Separation and Purification Technology,* 84:95-103.

Geosyntec Consultants, Inc., and Wright Water Engineering, Inc. (Geosyntec and Wright). 2012a. International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals. Updated, July 2012. Accessed at http://www.bmpdatabase.org/Docs/2012%20Water%20Quality%20Analysis%20Addendum/BMP%20Database%20Categorical_SummaryAddendumReport_Final.pdf.

Hinman, C. 2005. *Low Impact Development Technical Guidance Manual for Puget Sound.* Puget Sound Action Team. Washington State University Pierce County Extension. Puget Sound, WA. Accessed at http://www.psat.wa.gov/Publications/LID_tech_manual05/LID_manual2005.pdf.

Rushton, B.T. 2001. "Low-impact parking lot design reduces runoff and pollutant loads." *Journal of Water Resources Planning and Management,* 127(3):172–179.

Schueler, T.R., P.A. Kumble, and M.A. Heraty. 1992. *A Current Assessment of Urban Best Management Practices, Techniques for Reduction Non-Point Source Pollution in the Coastal Zone.* Prepared for Metropolitan Washington Council of Governments, Anacostia Restoration Team, Department of Environmental Programs, Washington D.C.

Strecker, E.W., M.M. Quigley, B. Urbonas, and J. Jones. 2004. "Analyses of the expanded EPA/ASCE International BMP Database and potential implications for BMP design." In *Proceedings of the World Water and Environmental Resources Congress*, American Society of Civil Engineers, Salt Lake City, UT, June 27–July 1, 2004.

K.2.2 Bioretention, Infiltration Trenches, Bioswales, Planter Boxes

Barrett, M.E., M. Limouzin, and D.F. Lawler. 2013. "Effects of media and plant selection on biofiltration performance." *Journal of Environmental Engineering*. 139(4):462-470.

Davis, A.P. 2007. "Field performance of bioretention: Water quality." *Environmental Engineering Science,* 24(8):1048–1063.

Davis, A.P., W.F. Hunt, R.G. Traver, and M. Clar. 2009. "Bioretention technology: Overview of current practice and future needs." *Journal of Environmental Engineering,* 135(3):109–117.

Davis, A.P., R.G. Traver, W.F. Hunt, R. Lee, R.A. Brown, and J.M. Olszewski. 2012. "Hydrologic performance of bioretention storm-water control measures." *Journal of Hydrologic Engineering,* 17(5):604–614.

Hathaway, J.M., W.F. Hunt, and S.J. Jadlocki. 2009. "Indicator bacteria removal in stormwater best management practices in Charlotte, North Carolina." *Journal of Environmental Engineering,* 135(12):1275–1285.

Hathaway, J.M., W.F. Hunt, A.K. Graves, and J.D. Wright. 2011. "Field evaluation of bioretention indicator bacteria sequestration in Wilmington, NC." *Journal of Environmental Engineering,* 137(12):1103–1113.

Hatt, B.E., T.D. Fletcher, and A. Deletic. 2009. "Hydrologic and pollutant removal performance of stormwater biofiltration systems at the field scale." *Journal of Hydrology*. 365(3–4): 310-321.

Hunt, W.F., and W.G. Lord. 2006. *Bioretention Performance, Design, Construction, and Maintenance.* North Carolina Cooperative Extension, Raleigh, NC.

Hunt, W.F., A.R. Jarrett, J.T. Smith, and L.J. Sharkey. 2006. "Evaluating bioretention hydrology and nutrient removal at three field sites in North Carolina." *Journal of Irrigation and Drainage Engineering,* 132(6):600–608.

Hunt, W.F., J.T. Smith, S.J. Jadlocki, J.M. Hathaway, and P.R. Eubanks. 2008. "Pollutant removal and peak flow mitigation by a bioretention cell in urban Charlotte, NC." *Journal of Environmental Engineering,* 134(5):403–408.

Hunt, W.F., A.P. Davis, and R.G. Traver. 2012. "Meeting hydrologic and water quality goals through targeted bioretention design." *Journal of Environmental Engineering,* 138(6): 698-707.

Jones, M.P., and W.F. Hunt. 2009. "Bioretention impact on runoff temperature in trout sensitive waters." *Journal of Environmental Engineering,* 135(8):577–585.

Kim, H., E.A. Seagren, and A.P. Davis. 2003. "Engineered bioretention for removal of nitrate from stormwater runoff." *Water Environment Research*, 75(4):355–367.

Li, H., and A.P. Davis. 2008. "Urban particle capture in bioretention media, I: Laboratory and field studies." *Journal of Environmental Engineering,* 143(6):409–418.

Li, H., L.J. Sharkey, W.F. Hunt, and A.P. Davis. 2009. "Mitigation of impervious surface hydrology using bioretention in North Carolina and Maryland." *Journal of Hydrologic Engineering,* 14(4):407–415.

Li, M.-H., C.Y. Sung, M.H. Kim, and K.-H. Chu. 2010. "Bioretention for Stormwater Quality Improvements in Texas: Pilot Experiments." Prepared for Texas A&M University in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Luell, S.K. 2011. "Evaluating the Impact of Bioretention Cell Size and Swale Design in Treating Highway Bridge Deck Runoff." A thesis submitted to the graduate faculty of North Carolina State University. Raleigh, NC.

Olszewski, J.M., and A.P. Davis. 2013. "Comparing the Hydrologic Performance of a Bioretention Cell with Predevelopment Values." *Journal of Irrigation and Drainage Engineering,* 139(2):124-130.

Passeport, E., W.F. Hunt, D.E. Line, R.A. Smith, and R.A. Brown. 2009. "Field study of the ability of two grassed bioretention cells to reduce stormwater runoff pollution. "*Journal of Irrigation and Drainage Engineering* 135(4):505–510.

Ramsey, C.G., and H. R. Sleeper. 1988. *Architectural Graphic Standards* (Eighth Ed.), Somerset, NJ: John Wiley & Sons.

Rusciano, G. M., and C.C. Obropta. 2007. "Bioretention column study: fecal coliform and total suspended solids reductions." *Transactions of the American Society of Agricultural and Biological Engineers,* 50(4):1261–1269.

Stander, E.K., and M. Borst. 2010. "Hydraulic test of a bioretention media carbon amendment." *Journal of Hydrologic Engineering,* 15(6):531–536.

K.2.3 Permeable Pavement

Brattebo, B.O., and D.B. Booth. 2003. "Long-term stormwater quantity and quality performance of permeable pavement systems." *Water Research,* 37(18):4369–4376.

Brown, R.A., D.E. Line, and W.F. Hunt. 2012. "LID treatment train: Pervious concrete with subsurface storage in series with bioretention and care with seasonal high water tables." *Journal of Environmental Engineering,* 138(6):689–697.

Collins, K.A., W.F. Hunt, and J.M. Hathaway. 2008. "Hydrologic comparison of four types of permeable pavement and standard asphalt in eastern North Carolina. "*Journal of Hydrologic Engineering,* 13(12):1146–1157.

Collins, K.A., W.F. Hunt, and J.M. Hathaway. 2010. "Side-by-side comparison of nitrogen species removal for four types of permeable pavement and standard asphalt in eastern North Carolina." *Journal of Hydrologic Engineering,* 15(6):512–521.

Dierkes, C., L. Kuhlmann, J. Kandasamy, and G. Angelis. 2002. "Pollution retention capability and maintenance of permeable pavements." In *Proc. 9th International Conference on Urban Drainage, Global Solutions for Urban Drainage*, September 8–13, 2002, Portland, OR.

Eck, B.J., R.J. Winston, W.F. Hunt, and M.E. Barrett. 2012. "Water quality of drainage from permeable friction course." *Journal of Environmental Engineering,* 138(2): 174-181.

Fassman, E.A., and S.D. Blackbourn. 2010. "Urban runoff mitigation by a permeable pavement system over impermeable soils." *Journal of Hydrologic Engineering,* 15(6):475–485.

Fassman, E.A., and S.D. Blackbourn. 2011. "Road runoff water-quality mitigation by permeable modular concrete pavers." *Journal of Irrigation and Drainage,* 137(11):720–729.

Gilbert, J.K., and J.C. Clausen. 2006. "Stormwater runoff quality and quantity from asphalt, paver, and crushed stone driveways." *Connecticut. Water Research,* 40:826–832.

Myers, B.R., S. Beecham, J.A. van Leeuwen, and A. Keegan. 2009. "Depletion of *E. coli* in permeable pavement mineral aggregate storage and reuse systems." *Water Science and Technology,* 60(12):3091–3099.

Tota-Maharaj, K., and M. Scholz. 2010. "Efficiency of permeable pavement systems for the removal of urban runoff pollutants under varying environmental conditions." *Environmental Progress and Sustainable Energy,* 29(3):358–369.

Tyner, J.S., W.C. Wright, and P.A. Dobbs. 2009. "Increasing exfiltration from pervious concrete and temperature monitoring." *Journal of Environmental Management,* 90:2636–2641.

Wardynski, B.J., R.J. Winston, and W.F. Hunt. 2013. "Internal Water Storage Enhances Exfiltration and Thermal Load Reduction from Permeable Pavement in the North Carolina Mountains." *Journal of Environmental Engineering,* 139(2):187-195.

Yong, C.F., A. Deletic, T.D. Fletcher, and M.R. Grace. 2011. "Hydraulic and treatment performance of pervious pavements under variable drying and wetting regimes." *Water Science and Technology,* 64(8):1692–1699.

K.2.4 Constructed Wetlands

Davies, C.M., and H.J. Bavor. 2000. "The fate of stormwater-associated bacteria in constructed wetland and water pollution control pond systems." *Journal of Applied Microbiology,* 89(2):349–360.

Hathaway, J.M., and W.F. Hunt. 2010. "Evaluation of storm-water wetlands in series in Piedmont North Carolina. "*Journal of Environmental Engineering,* 136(1):140–146.

Jones, M.P., and W.F. Hunt. 2010. "Effect of stormwater wetlands and wet ponds on runoff temperature in trout sensitive waters." *Journal of Irrigation and Drainage Engineering*, 136(9):656–661.

Moore, T.C., W.F. Hunt, M.R. Burchell, and J.M. Hathaway. 2011. "Organic nitrogen exports from urban stormwater wetlands in North Carolina. "*Ecological Engineering,* 37(4):589–594.

Struck, S.D., A. Selvakumar, and M. Borst. 2008. "Prediction of effluent quality from retention ponds and constructed wetlands for managing bacterial stressors in storm-water runoff." *Journal of Irrigation and Drainage* 134(5):567–578.

K.2.5 Sand Filters

Barrett, M.E. 2010. "Evaluation of Sand Filter Performance." CRWR Online Report 10-07. Center for Research in Water Resources, Bureau of Engineering Research, University of Texas at Austin.

Barrett, M.E. 2003. "Performance, Cost, and Maintenance Requirements of Austin Sand Filters." *Journal of Water Resources Planning and Management,* 129(3):234–242.

Bell, W., L. Stokes, L.J. Gavan, and T. Nguyen. 1995. "Assessment of the Pollutant Removal Efficiencies of Delaware Sand Filter BMPs." City of Alexandria, Department of Transportation and Environmental Services, Alexandria, VA.

Horner, R.R. and C.R. Horner. 1995. *Design, Construction, and Evaluation of a Sand Filter Stormwater Treatment System. Part III. Performance Monitoring*. Prepared for Alaska Marine Lines. Seattle, WA.

U.S. Environmental Protection Agency (USEPA). 1999. *Storm Water Technology Fact Sheet: Sand Filters.* Office of Water, Washington D.C. EPA 832-F-99-007. http://www.epa.gov/owm/mtb/sandfltr.pdf.

K.2.6 Vegetated Swales

Bäckström, M. 2003. “Grassed swales for stormwater pollution control during rain and snowmelt.” *Water Science and Technology*, 48(9):123-132.

Bäckström, M., Viklander, M., and Malmqvist, P.A. 2006. Transport of stormwater pollutants through a roadside grassed swale.” *Urban Water Journal*. 3(2):55-67.

U.S. Environmental Protection Agency (USEPA). 2012. Grassed Swales. National Pollutant Discharge Elimination System (NPDES) Menu of Best Management Practices (BMPs). Updated July 23, 2012; accessed April 26, 2013, at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.

Yu, S. L., Kuo, J., Fassman, E.A., and Pan, H. 2001. “Field test of grassed-swale performance in removing runoff pollution.” *Journal of Water Resources Planning and Management*, 127(3):168-171.

K.2.7 Vegetated Filter Strips

Deletic, A, and T.D. Fletcher. 2006. “Performance of grass filters used for stormwater treatment—a field and modeling study. *Journal of Hydrology*. 317:261-275.

Deletic, A. 1999. “Sediment behavior in grass filter strips.” *Water Science and Technology*, 39(9):129-136.

Knight, E.M.P., W.F. Hunt, and R.J. Winston. 2013. “Side-by-side evaluation of four level spreader-vegetated filter strips and a swale in eastern North Carolina.” *Journal of Soil and Water Conservation*, 68(1):60-72

Winston, R.J., W.F. Hunt, D.L. Osmond, W.G. Lord, and M.D. Woodward. 2011. “Field evaluation of four level spreader-vegetative filter strips to improve urban storm-water quality.” *Journal of Irrigation and Drainage Engineering,* 137(3): 170-182.

Winston, R.J., W.F. Hunt, and W.G. Lord. 2011. “Thermal mitigation of urban stormwater by level spreader—Vegetative filter strips.” *Journal of Environmental Engineering,* 137(8): 707-716.

Zanders, J.M. 2005. “Road sediment: Characterization and implications for the performance of vegetated strips for treating road run-off.” *The Science of the Total Environment*, 339(1): 41-47.

K.2.8 Green Roofs

Berndtsson, J.C. 2010. “Green roof performance towards management of runoff water quantity and quality: A review.” *Ecological Engineering,* 36(4):351–360.

Kohler, M., M. Schmidt, F.W. Grimme, M. Laar, V.L. de Assunção Paiva, and S. Tavares. 2002. “Green roofs in temperate climates and in the hot-humid tropics—far beyond the aesthetics.” *Environment and Health,* 13:382–391.

Peck, S.W., and A. Johnston. 2006. *The Green Roof Infrastructure Monitor 8(1).* Accessed at http://www. greenroofs.org/resources/GRIM_Spring2006.pdf.

Schroll, E., J. Lambrinos, T. Righetti, and D. Sandrock. 2011. "The role of vegetation in regulating stormwater runoff from green roofs in a winter rainfall climate." *Ecological Engineering,* 37(4):595–600.

Tolderlund, Leila, 2010. *Design Guidelines and Maintenance Manual for Green Roofs in the Semi-Arid and Arid West.* University of Colorado Denver.

Wolf, D., and J.T. Lundholm. 2008. "Water uptake in green roof microcosms: Effects of plant species and water availability." *Ecological Engineering,* 33:179–186.

K.2.9 Green Streets

Federal Highway Administration (FHWA). 2002. *Storm Water Best Management Practices in an Ultraurban Setting: Selection and Monitoring*. Federal Highway Administration, Washington, DC.

Toronto and Region Conservation Authority. 2007. *Performance Evaluation of Permeable Pavement and a Bioretention Swale, Interim Report #3.* Seneca College, King City, Ontario.

Victoria Transport Policy Institute. 2007. "Traffic Calming: Roadway Design To Reduce Traffic Speeds and Volumes." *TDM Encyclopedia*. Victoria, BC, Canada. Accessed at http://www. vtpi.org/ tdm/tdm4.htm.

Winston, R.J., W.F. Hunt, S.G. Kennedy, J.D. Wright, and M.S. Lauffer. 2012. "Field evaluation of storm-water control measures for highway runoff treatment." *Journal of Environmental Engineering,* 138(1): 101-111.

Young, G.K., S. Stein, P. Cole, T. Kammer, F. Graziano, and F. Bank. 1996. *Evaluation and Management of Highway Runoff Water Quality.* Rep. No. FHWA-PD-96-032. Prepared for Federal Highway Administration, Washington, DC.

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APPENDIX L

Comprehensive Benefits Analysis of Water Quality Improvement Plan Strategies

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Appendix L
Comprehensive Benefits Analysis of Water Quality Improvement Plan Strategies

Final Technical Memorandum

November 2014

Prepared for:

City of San Diego, Storm Water Division

Prepared by:

HDR Engineering, Inc.
100 Oceangate, Ste. 1120
Long Beach, CA 90802

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Summary

The City of San Diego Storm Water Division ("Division") is developing Water Quality Improvement Plans (WQIPs) that consist of a range of structural and nonstructural strategies for meeting TMDL regulatory requirements in each watershed. However, the Division recognizes that these strategies differ with respect to their contribution to "additional" or "other" benefits to the local community, environment, and economy that are beyond specific water quality improvements in streams. This assessment has been implemented to provide the Division with supplemental information on these potential benefits. The Division aims to consider these other benefits in selecting strategies only in cases when strategies yield the same level of water quality improvements but which may produce markedly different levels of other benefits.

This document outlines a framework for assessing other benefits from these strategies. The framework assesses how each type of strategy could impact one or more types of other benefits. These additional benefits consist of various types of changes beyond water quality improvements in terms of environmental resources, quality of life, property values, business development, and others.

In the WQIPs, individual strategies are grouped into a series of categories that are defined as either 'Nonstructural' or 'Structural.' Over 20 categories of strategies have been defined based on their similarity in how they can improve water quality and include *Development Planning*, *Construction Management*, *Existing Development*, *Illicit Discharge*, *Detection, and Elimination (IDDE) Program*, *Public Education and Participation*, and *Enforcement Response Plan*.

The framework for assessing the potential for additional benefits from strategies has several dimensions including::

- *Strategy Categories* are defined by how they influence water quality improvements (see Section 2). There are three Structural and four Nonstructural types of strategy categories including.
  - *Structural Strategies*, as defined in the WQIP include: (a) Green infrastructure, (b) multi-use treatment areas, or (c) water quality improvement BMPs
  - *Nonstructural Strategies,* as defined in this assessment based on how these strategies aim to: (a) Improve Structural Systems Performance, (b) Increase the Number of Structural Systems, (c) Change Behavior; or (d) Reduce Pollutants Directly.
- *Benefit Categories* include a range of economic, social and environmental outcomes. This assessment determines the relevance and impact of each strategy category on a benefit category (see Section 3).

- *Impact Levels* of a strategy category in a benefit category is classified as either (a) monetizable, (b) measurable, (c) potential, or (d) not applicable. (See Section 3). These impact levels are indented to provide *order of magnitude* information about the potential impact of a strategy on each type of benefit.

- A scoring system is established for the magnitude of benefits evaluation to compare different strategies (see Section 3). In addition, the total number of applicable benefits is provided for additional information about the relative advantage of different strategies.

A discussion and rationale for assessing the level of impact for a given strategy on a benefit category is provided in Section 4. This assessment is intended to be an initial, order of magnitude of benefits of different strategies. It can only be an illustrative assessment since details on the design and location of any individual strategy is not available at this stage. The framework however is intended to indicate how and to what degree benefits could be estimated once a strategy is in place. As an order of magnitude assessment, strategies with measurable and monetizable would be expected to exhibit successively higher levels of estimable benefits compared to strategies that are classified as only having a potential connection to benefits.

The results, as presented in Section 5, indicate that structural strategies (especially, Green Infrastructure and Multiuse Treatment Areas) have the highest potential to generate sizable benefits. However, a number of nonstructural strategies (e.g. Initiatives to Change Behavior for Existing Development, Priority Development Projects, Construction Management, Public Education and Enforcement, among others) could also provide additional benefits. Many other non-structural strategies have the potential to generate a wide range of different benefits for the community.

A cross-cutting theme in this assessment is the impact of strategies on property values and business development. Some strategies, such as ones that foster on-site water retention and reduction of street debris, have the potential to provide tangible and intangible benefit to communities and local businesses by reducing water and clean-up costs and providing an overall improved aesthetic environment. Depending on where and how a strategy is implemented, benefits can be higher or lower. The literature review in Appendix 1 discusses cases where these benefits have measured.

A next step for this assessment would entail site-specific evaluations of strategies and potential additional benefits of WQIP at a planning level. As strategies become more defined and specific data becomes available on project conditions, this framework could be adapted further to create more detailed results for prioritizing strategies. This step would include applying current research to site specific projects to more direct monetize and quantify the outcomes of strategies in terms of cost savings and property value enhancements. Better still would be a pre- and post-monitoring program to assess the singular and combined effects of strategies to different stakeholders.

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List of Tables

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
ac	Acres
BCA	Benefit Cost Analysis
BES	Bureau Of Environmental Services
BMP	Best Management Practice
Btu	British Thermal Unit
CAMX	California-Mexico Power Area
CEA	Cost-Effectiveness Analysis
CLRP	Comprehensive Load Reduction Plan
CNT	Center For Neighborhood Technology
CO2	Carbon Dioxide
CSO	Combined Sewer Overflow
DOT	Department Of Transportation
EIA	Economic Impact Analysis
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GI	Green Infrastructure
HOA	Home Owner's Association
IDDE	Illicit Discharge, Detection, And Elimination
kWh	Kilowatt Hour
LACDPW	Los Angeles County Department Of Public Works
LID	Low Impact Development
M Wh	Mega Watt Hour
MMSD	Milwaukee Metropolitan Sewage District
MODA	Multi-Objective Decision Analysis
MS4	Municipal Separate Storm Sewer System
NOx	Nitric Oxide And Nitrogen Dioxide
NPV	Net Present Value
NRDC	Natural Resources Defense Council
O&M	Operations And Maintenance
O3	Oxide
PDP	Priority Development Projects
PFC	Permeable Friction Course
PGA	Pollutant Generating Activities

Acronyms and Abbreviations (continued)

Acronym or Abbreviation	Definition
PM	Particulate Matter
PWD	Philadelphia Water District
QMRA	Quantitative Microbial Risk Assessment
SO2	Sulfur Dioxide
SPU	Seattle Public Utilities
SROI	Sustainable Return On Investment
TBL	Triple Bottom Line
TIGER	Transportation Investment Generating Economic Recovery
TMDL	Total Maximum Daily Load
UTC	Urban Tree Canopy
WAMP	Watershed Asset Management Plan
WERF	Water Environment Research Foundation
WQIP	Water Quality Improvement Plan

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1 Introduction

The City of San Diego Storm Water Division (Division) has prepared many potential strategies as part of its Water Quality Improvement Plan (WQIP). These strategies have identified a range of structural best management practices (BMPs) (e.g., a constructed runoff reduction system, such as a bio-swale), and nonstructural BMP activities (e.g., programs that promote installation of constructed systems, or reduce pollutants directly through education and outreach). This memo seeks to assess the potential for strategies to generate “additional” or “other” benefits beyond water quality improvements. The Division seeks such information to contribute to prioritization of strategies that meets regulatory requirements and generates the best value for the community and local businesses.

The concept for evaluating the other benefits of proposed strategies has been under discussion since April 2014. A technical memo was developed as an initial task to classify additional benefits from the Division’s stormwater management strategies. That memo is contained in Appendix 1 and includes a literature review of potential benefit categories and case studies of green infrastructure program benefits. The economic framework was presented to stakeholders at a meeting on May 20, 2014. Feedback was elicited during and after that meeting, and has been incorporated into this document and to the Division’s current approach to evaluating strategies (see presentation, handout, and comments from workshop in Appendix 2).

The next several sections in this document present the approach and draft evaluation of additional benefits. The evaluation has been applied to a comprehensive list of strategies from the City’s three draft WQIPs (Mission Bay, Los Peñasquitos, and San Dieguito). The framework entails the characterization of strategy categories by type of impact (Section 2), definition of potential types of benefit categories (Section 3) and a classification of benefits for each strategy category (Section 4). Results of this evaluation are contained in Section 5.

This assessment of additional benefits of WQIP strategies is conducted for initial planning purposes only. As strategies become more defined and specific data becomes available on project conditions, this framework could be adapted further to create more detailed results for prioritizing strategies. This step would include applying current research to site specific projects to more directly monetize and quantify the outcomes of strategies areas such as recreational, property value and business development benefits.

2 Strategy Classifications

The WQIP identifies a number of strategy categories as either “Nonstructural” or “Structural”, and in terms of whether they are Jurisdictional Strategies or Optional Jurisdictional Strategies. Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." In the analysis of benefits, the main distinction is between Nonstructural or Structural types which are defined in the following ways.

Nonstructural Strategies include “those actions and activities intended to reduce storm water pollution, which do not involve construction of a physical component or structure to filter and treat storm water.” Individual strategies are grouped into over 25 different categories including: *Development Planning*, *Construction Management*, *Existing Development*, *Illicit Discharge, Detection, and Elimination (IDDE) Program*, *Public Education and Participation*, *Enforcement Response Plan*, and *Non-JRMP Strategies*. For each watershed, a list of potential nonstructural strategies has been developed that reflect the needs, opportunities and constraints in different locations. In general, many of these initiatives have been implemented by the Division for many years and are integral to regulatory compliance on a watershed-specific basis.

Nonstructural strategy categories are further defined in this assessment by *how* they improve water quality, which in turn indicates how they may generate other benefits. For example, four types of mechanisms include the ways in which strategies:

- ***Improve Structural Systems Performance:*** These include strategies that relate to new design standards and performance monitoring would be measured by the improvement in the performance of installed structural systems. The benefits of these nonstructural strategies would ultimately draw from the benefits of structural systems that are implemented.
- ***Increase the Number of Structural Systems*:** These strategies aim to increase the rate of BMP adoption is due to training in the community or general promotion of BMPs, lead to benefits whenever they are installed. The outcome of these strategies then depends on the number of *additional* systems that are installed.
- ***Change Behavior*:** These strategies target efforts to encourage improved environmental stewardship and storm water protection by residents and businesses throughout the community. Various types of actions that people may take who become more aware of environmental impacts through these strategies include adoption of rain barrels, reducing litter, and reducing unnecessary levels of pesticides, herbicides and fertilizers.
- ***Reduce Pollutants Directly:*** These strategies include those that aim to directly control pollution through actions that the Division and other public agencies can take independently, such as internal training, enforcement and administrative changes. These strategies can lead to behavior change by individuals but initially through a focus on public entities.

Structural Strategies, in contrast to Nonstructural strategies, are physical infrastructure that are designed for site-specific conditions and placed strategically across a watershed to improve water quality. The effectiveness and feasibility of implementing any of these BMPs varies depending on their design and site conditions. For example, the effectiveness of a BMP for enhanced infiltration capacity of a watershed depends on amenable soil types. Other site-specific considerations include the physical land area available for effective implementation and maintenance. Also, the capital and maintenance costs of a BMP influence its feasibility for the Division, especially in comparison to other BMPs which can be implemented more cost-effectively. The structural strategies that have been identified as potentially suitable for San Diego watersheds and have been classified as one of three types: (1) green infrastructure, (2) multiuse treatment areas, and (3) water quality improvement BMPs.

- ***Green Infrastructure*** covers a range of BMPs that are designed to be integrated in a broader site plan to maintain healthy waters, provide multiple environmental benefits, and support sustainable communities. Green infrastructure is distinguished from other methods by making deliberate and effective use of vegetation and soil to manage storm water.

- ***Multiuse Treatment Areas*** in the Water Quality Improvement Plan are identified as large-scale treatment areas such as multiuse basins and stream, channel, and habitat rehabilitation projects. These systems are designed as regional facilities that can receive flows from neighborhoods or larger areas and become cost-effective solutions that provide multiple benefits. For example, such systems can be integrated in public spaces, such as soccer fields and parks, which provide recreational areas and flood control, ground water recharge, restoration, habitat enhancement, and recreation. In addition stream bank projects that reduce erosion can improve water quality and simultaneously improve habitat.

- ***Water Quality Improvement BMPS*** include systems that supplement the design performance of existing infrastructure. For example, systems that segregate trash includes inlet devices, such as trash guards or racks that capture debris before they enter surface waters. Another example are proprietary commercial products that often aim to use settling, filtration, absorptive/adsorptive materials, vortex separation, and sometimes vegetative components to remove pollutants from runoff. Finally, dry weather flow separation and treatment projects target non-storm water dry season flows and divert these flows for treatment either on-site or to sanitary sewer systems and ultimately wastewater treatment plants.

Overall, 30 different groups of strategies have been classified as either “Jurisdictional” (strategy types numbered 1-23, in Table 2 and Table 6 or “Optional Jurisdictional” (strategies types numbered 24-30, in Table 3 and Table 7). Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." The number ordering for these strategies follows from documents provided by the Division and reflects the most comprehensive list of current strategies under consideration. Specific strategies have also been identified by the Division within each strategy group.

3 Benefit Categories and Levels of Impact

Stormwater management strategies can generate various types of benefits and have different levels of impact. Economic research has shown that stormwater management strategies can generate a range of benefit categories with economic, environmental and social impacts for the local residents, businesses, and public agencies. The level of impact of a strategy can differ across benefit categories and depends on the design of the strategy, site conditions where the strategy is implemented, and characteristics in the community. Estimation of economic benefits from a strategy depends on the degree to which linkages can be quantified between strategy and a benefit category and then available economic literature to value this change. In some cases, only a part of the link between a strategy and a benefit category can be quantified (e.g. the volume of water retained by a green infrastructure system can be measured, but not its impact on stream bank stabilization).

3.1 Description of Benefit Categories

This section below discusses a number of benefit categories that are found in economic literature. They are grouped by financial, environmental and social dimensions. A broader discussion from the literature is contained in the Appendix 1.

Financial Benefits

- ***Water Cost Savings:*** This type of benefit could occur when potable water needed for landscaping, washing or other property maintenance is reduced. Green infrastructure strategies could enable such savings if water retention reduces water demand, or some part of the system improves irrigation efficiency. The reduction in demand lowers water costs. These savings could be quantified and monetized if the volumes of water retained at a site can be measured.

- ***Energy Cost Savings:*** Green infrastructure can generate energy cost savings in several ways. For example, buildings which are adjacent to trees or which install green roofs can benefit from lower the heating and cooling energy costs because of shading and insulation, respectively. Some research suggests that if such green infrastructure system were installed throughout a city, the overall ambient temperature would decline and which would in turn reduce cooling loads for other buildings. Finally, in cases when green infrastructure provides water storage that lowers pumping costs, there would be a corresponding reduction in energy costs.

Environmental Benefits

- ***Flood Risk Reduction:*** Reduced runoff in an urban watershed can reduce the frequency and severity of flooding in downstream neighborhoods in some cases. The magnitude of these benefits though depends on if such a neighborhood is downstream and on the design and scale of a strategy that reduces flooding. Other factors include rainfall conditions, soil characteristics, slope, elevation and watershed characteristics. A first step in quantifying the potential for flood risk reduction benefits requires an understanding how much water is retained.

- ***Air Particulate Entrapment:*** Some green infrastructure systems can trap airborne pollutants, such as particulate matter (e.g. PM10), directly from the environment on their leaves and in turn reduce adverse human health impacts.[1] The total amount of particulate trapping depends on the type of vegetation, and local climate conditions. For trees, the US Forest Service published a report that provides benchmark values for use in calculations.[2] This type of benefit can be quantified and potentially monetized based on the amount and type of plants.

- ***Climate Impacts:*** Carbon sequestration is a natural process in which plants store carbon in biomass and soils as they grow. When atmospheric carbon dioxide is taken up by trees, grasses, and other plants, it can reduce greenhouse gas effects on the planet. The amount of carbon that can be sequestered by a green infrastructure system depends on the above ground quantity of biomass of the tree, green roof or bio-swale. Economic valuation of climate change effects can be used to monetize carbon sequestration.

- ***Habitat Related Benefits:*** Green infrastructure that can provide habitat benefits include strategies that create new habitat areas, or improve existing ones. For example, vegetated infiltration systems can improve the habitat for flora and fauna, birds, and insect species. These different types of habitats are usually small in size and have limited impacts. Greater benefits may arise from large-scale strategies that enhance habitat connectivity in existing corridors. This type of benefit is readily quantified based on the acreage and plantings at a green infrastructure site, or stream bank stabilization effects, but more difficult to monetize because of limitations in economic research.

- ***Air Quality Emission Reduction:*** The total amount of reduction in criteria air contaminant emissions, such as particulate matter, from a power plant is directly tied to the reduction in energy use as discussed above. Energy savings are readily converted to its emission rate reductions by utilizing data from EPA and other public sources. Reduction in air pollution would generate health-related benefits for people. This benefit can be quantified and monetized if information is available on the amount of water and energy reduced at a treatment facility.

- ***GHG Emission Reduction:*** Similar to air quality emission reductions, energy demand reduction also reduces greenhouse gas emissions. The tons of greenhouse gas emissions are computed from the same data sources as criteria air contaminants. The economic damage caused by greenhouse gas emissions are broadly related to changes in productivity and damage costs.

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[1] Center for Neighborhood Technology, The Value of Green Infrastructure. 2010

[2] http://www.fs.fed.us/psw/programs/uesd/uep/products.shtml

Social / Community Benefits

- ***Property Value Enhancement:*** Green infrastructure and other strategies can lead to enhanced property values under a variety of circumstances. For example, strategies that improve the overall visual appearance of a community simply by having planted material, street trees and bioswales among impervious surfaces have been shown to enhance value of nearby properties. In addition, some BMPs strategies aim to directly reduce litter or debris from public spaces to make it more visually appealing. These effects improve the overall quality of life in those neighborhoods. Benefits can be quantified by measuring the number of properties that are adjacent to the green infrastructure. Monetization of the effect would depend on the applicability of economic research on a site specific basis.
- ***Recreational Benefits:*** Certain green infrastructure strategies provide recreational benefits if they facilitate pedestrian, bicycle use, or connect to an existing recreational corridor or trails. Benefits would be monetized by the number of participants in a recreational activity at a site and their value per use. Other quantitative measures include the number and type of design features that offer recreational options.
- ***Business Development & Jobs:*** Green infrastructure, such as comprehensive green street designs, and initiatives to reduce street debris can lead to an enhanced sense of place, and increase in foot traffic that can support retail activity. Additionally, spending on capital investments and operations and maintenance (O&M) leads to job creation. This benefit can be measured by assessing the number of jobs created in an area where a green infrastructure strategy is implemented. In addition, these jobs can be associated with wider economic development benefits.
- ***Crime Reduction:*** Research suggests that fewer crimes occur near buildings with trees and non-invasive vegetation. Maintained areas of vegetation encourage informal social gatherings outdoors. Incidence of crime declines when with the presence of people and possibly by psychological precursors to crime.
- ***Public Education/ Environmental Stewardship:*** Promoting strategies that seek to change people's behaviors and make them more aware of their environmental impacts helps to cultivate a *stewardship perspective* in the community about its local natural resources. Quantification of this type of benefit may be measured in terms of how many people are reached with messages of programs aimed to enhance knowledge and ultimately actions towards to improve stormwater management.
- ***Heat Island Effect:*** Trees and other vegetation can reduce ambient temperatures in cities that have higher air temperatures. Lower temperatures can reduce health effects especially in populations that are at risk of heat stroke. Additionally, the overall lowering of temperatures can reduce cooling needs at properties located within the area. This type of benefit is only quantifiable in cases where the strategy is applied over a large scale.

- ***Noise Reduction:*** Some green infrastructure systems, such as wetlands or trees, are effective in reducing ambient noise because they can absorb it. This is also true for porous concrete and green roofs, but there is limited research in quantifying these benefits.

3.2 Characterization of the Benefit Level from a Strategy

The potential magnitude of benefits differs across strategy types. To account for these differences, four 'levels' are defined that represent a decreasing association between the impact of a strategy and a benefit category. These levels include:

Monetizable – The level of benefits indicates impacts that can be quantified and where economic research has been produced to determine a monetary value.

Measurable – There exists a connection for some measure of non-monetary impact can be identified and measured, even if economic research is not available to monetize the impacts.

Potential - A conceivable connection exists between a strategy and benefit category but it is not likely to be measurable.

Not Applicable - There is no discernible connection between a strategy and benefit category.

At this stage in program implementation and project design, the impact of each strategy on a benefit category can only be considered to be an order of magnitude assessment. An estimation of the actual impact would be highly uncertain since most strategies currently lack site-specific data about the design and implementation. Instead, these levels of impact are intended to provide separable categories that indicate the order of magnitude of benefits that a strategy may be able to generate. That is, it is only possible to assess the likelihood that a project can generate monetizable benefits, not the actual size of monetizable benefits.

At the same time, these four categories are intended to provide a broad degree of separation between strategies in terms of their measurable connection with each benefit category. For instance, if a strategy can be classified as having monetizable benefits, then its overall level of measurable benefits can be reasonably assumed to be higher than another strategy that is classified as being quantifiable, even if only in part. By the same rationale, these classifications would likely have more direct impact for a benefit category than a strategy whose impact can only be presumed

This assessment aims to achieve consistency in evaluations within a specific strategy outcome group, as well as across strategy outcome groups. While some strategies have design or location specifications (e.g., total acres of bioretention), or target certain groups (developers vs. residential), others entail broad descriptions. Due to this uncertainty, the evaluation has taken a conservative approach to drawing conclusions about the magnitude of benefits that could arise from a strategy.

3.3 Scoring System

A scoring system is established to support comparisons of strategies with respect to the potential benefits they can generate (see Table 1). Each benefit level is assigned a point value that has been established through discussions with the Division. The values are intended to provide an indication of the strategy's impact across all benefit categories. In this case, potentially monetizable benefits are assigned a higher score than one that is only quantifiable (and not monetizable). This approach is intended to separate the types of benefits that are likely to be larger in magnitude from others that cannot be monetized nor quantified.

Table 1. Overview of Benefit Scoring

Level	Description	Point Value
Monetizable	Strategy can realize quantifiable impacts, and sufficient economic evidence supports placing a dollar value on these impacts.	1
Measurable	Strategy can realize quantifiable impacts, but lacks sufficient economic evidence to support placing a dollar value on these impacts.	0.667
Potential	Strategy most likely provides a positive impact, but the magnitude of the impact is uncertain.	0.333
Not Applicable	Strategy will not impact the benefit category in any meaningful way.	0

This scoring system places higher weight on strategies which may generate benefits that can be monetized (3 times the weight of a potential benefit level). Accordingly, in some cases a strategy that influences many additional benefit categories at a "*Potential*" level could score lower than one with fewer categories but with "*Monetizable*" impacts. This scoring system is designed for that type of result to give greater emphasis on strategy impacts that can be measured and are thus more tangible. Potential impacts are circumstantial and small, as compared to more significant impacts that can be measured and monetized. Furthermore, the implications of this scoring system have been taken into account in a consistent approach in determining which impacts of strategy are classified as monetizable, measureable or potential.

This scoring system is applied to the strategies in Table 2 through Table 7. This scoring system is only relevant for comparing strategies with respect to additional benefits, not in ways that influence a ranking towards meeting permit requirements and/or encourages other program objectives such as habitat restoration.

In addition, the total number of applicable benefit categories is also shown in Table 2 through Table 7 for additional reference on the impact of these strategies.

4 Framework for Assessment of Strategies

Determination of the applicability of benefits for each strategy depends primarily on the assignment of a strategy to one of the structural or nonstructural categories (defined in Section 2). Consistency in the applicability of a benefit category (defined in Section 3) for a strategy is maintained by jointly evaluating all strategies of a specific type. This section discusses the framework for assessing potential additional benefits that can arise from the implementation of each strategy. The aim of this exercise is to apply a consistent and transparent rationale for each strategy. Since available evidence is limited with respect to each strategy, the application of a consistent set of assumptions to each strategy underlies the basis for determining (a) which benefit categories are applicable, and (b) the potential magnitude of benefits, if a category is applicable.

The approach to assigning a magnitude level began with an assessment of the strategy for which the most information is available about its potential impact: Green Infrastructure (Ref 19). This type of strategy is used as a benchmark for assigning benefit categories and potential magnitudes of benefits due to the availability of evidence from projects implemented elsewhere in the U.S. To illustrate this approach for Green Infrastructure (Ref 19), consider the rationale below:

- In some cases, sufficient information available about the specific strategies specifies the area of bioretention and permeable pavement to be installed and the location of the project. Due to the size of these initiatives, and knowing that the vegetation can improve air quality through the uptake of criteria pollutants and improve the climate through carbon sequestration, it is assumed that the total pollutant and CO_2 removal from the atmosphere can be quantified. These quantified amounts of pollutant and CO_2 can then be monetized using standard practices that are currently being used to value these impacts.
- Additionally, it is assumed that these projects will provide aesthetic improvements to the existing site, which can be quantified with information regarding the number of properties within a certain radius and the property value changes.
- These sites will also need to be maintained, which will require spending on jobs, and depending on the specific site location, the improved aesthetics can also improve businesses located near the site.
- The total land area of the bioretention and permeable pavement will allow for quantifying the amount of rain water which gets absorbed onsite, and does not cause localized flooding, where applicable.
- The remaining other benefit categories are assumed to see positive impacts. For example, GHG emission reductions may occur from the lifecycle CO_2 emissions for permeable pavement being lower than the lifecycle CO_2 emissions of asphalt or pavement. However, there is not enough information at this time to accurately quantify that impact.

- Similarly, permeable pavement absorbs less heat than conventional pavement, which is a benefit for Urban Heat Island reduction. The amount of heat, and how that will affect public health cannot be quantified.

The potential impacts of all other strategies have been evaluated relative to the benchmark as established by the above assumptions for green infrastructure. As an example, the first group of strategies evaluated below, All Development Projects (Ref 1). focuses on improving existing systems performance. It is assumed that specific actions, such as administrative training or increased monitoring, will have positive impacts for the same benefit categories as a green infrastructure project. But since there is no way to quantify any of those impacts, the magnitude of benefits is assumed to be lower.

The remainder of this section discusses the assessment of Jurisdictional and Optional Jurisdictional Strategies. Note that these strategies represent the latest consideration in an evolving process of identification, specification and assessment. Not all strategies have been implemented or have plans for immediate implementation. At the same time, the specification of the design standards also varies from strategy to strategy. This assessment takes into account the *potential* benefits that may occur, given the information available, and assumptions that are listed in each strategy.

4.1 Jurisdictional Strategies

This section discusses the rationale and methodology for assigning scoring categories to the Jurisdictional Strategies, based on the most recent description of the strategy. This list of individual strategies has been grouped according to the same categories that are proposed for the draft WQIPs and are presented in the same chronological order. The information found in the parenthesis next to the strategy group name (*Ref X*), refers to the number in the far left columns of Table 2 and Table 6. Note that in some cases (e.g., Commercial, Industrial, Municipal, and Residential Facilities and Areas) the strategies are separated into two types (i.e., Improve Structural Systems Performance and Initiatives to Change Behavior) based on the specific ways in which a strategy creates benefits.

4.1.1 All Development Projects (Ref 1)

Strategies in this group consist of administrative and other tasks that center on improving the structural system's performance. Many of these types of strategies focus on broad initiatives such as training or source control. The list of strategies includes the following:

- Administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.
- Investigation and research of emerging technology.
- Train staff on LID regulatory changes and LID practices.
- Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities. Ensure consistency with the City of San Diego's BMP Design Manual.

- Develop and implement Green Infrastructure Program and Guidelines.
- Develop Design Standards for Public LID BMPs.
- Create Right-of-Way Design Manual.

In scoring these strategies, it is assumed that the programs that target the administration or enforcement of BMPs would mostly affect the same benefit categories as a Green Infrastructure (GI) project which increases the acres of bioretention, but on a smaller scale. It is assumed that these projects would generate a positive impact but due to the uncertainty of the implementation and magnitude of the effect of these strategies, it cannot be measured.

Some of the broad initiatives are deemed to have too much uncertainty to reasonably assign a specific benefit level. It is however reasonable to assume that overall public awareness and knowledge of the issue will increase.

4.1.2 Priority Development Projects (PDPs) (Ref 2)

Similar to the strategies in the All Development Projects section, PDP initiatives are assumed to increase the number of structural systems and improve existing structural systems. These strategies include the following:

- For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.
- Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.
  - Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.
  - Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.
  - Amend BMP Design Manual for nurseries and garden centers.
  - Amend BMP Design Manual for auto-related uses.
- Administer a program to inspect and enforce updated BMPs in BMP Design Manual
- Develop and administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects).

Scoring the impact of programs that target the administration or enforcement of BMPs would mostly affect the same benefit categories as a green infrastructure project which increases the acres of bioretention, but on a smaller scale. Initiatives that focus on updating various components of the design manual are assumed to increase the efficiency of the already existing systems. However, the total magnitude of this improvement cannot be estimated without additional information, and thus other benefits for this group cannot be measured.

4.1.3 Construction Management (Ref 3)

There is one specific strategy under this group, and it is assumed it will improve structural system performance. Construction Management strategy is:

- ❖ Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.

The scoring for this strategy is assumed to be the same as previously discussed strategies that improve the performance of existing systems.

4.1.4 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Improve Structural Systems Performance (Ref 4)

The specific initiatives under this strategy group focus on improving structural systems performance. These strategies differ from the strategies in the next group, which also are included under Commercial, Industrial, Municipal, and Residential Facilities and Areas in the Water Quality Improvement Plan, but target a different outcome. Administering programs which require minimum BMPs are assumed to affect the same benefit categories as a GI project which increases the acres of bioretention, but a smaller scale. These strategies include:

- ❖ Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.
    - ➢ Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include require sweeping, catch basin cleaning and maintenance of private roads and parking lots in targeted areas.
    - ➢ Power-washing minimum BMPs: Outreach to property managers and trash haulers to elevate the emphasis of washing as a pollutant source. Emphasize non-compliant washing as an enforceable violation.
    - ➢ Implement property based inspections.
    - ➢ Review policies and procedures to ensure discharges from swimming pools meet permit requirements.

Strategies that target pollutants directly, such as the power-washing minimum BMPs, can be assumed to reduce the amount of pollutants entering the environment. However, while these strategies protect habitats and improving aesthetics, the total amount of pollutants reduced cannot be measured until more information is known regarding the current level of pollutant discharges, and how many people are targeted as part of this initiative. These initiatives are assumed to require some level of public outreach or promotion, and public awareness of these issues will be raised.

4.1.5 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Initiatives to Change Behavior (Ref 5)

While also focusing on Commercial, Industrial, Municipal, and Residential Areas, these strategies seek to initiate changes in behavior. This list includes:

- Implement pet waste program
- Consider installing trash bins, pet waste bag dispensers and pickup services on Rose Creek Bicycle Path and Rose Canyon Bicycle Path.
- Promote and encourage implementation of designated BMPs for residential and non-residential areas.
- Residential BMP: Rain Barrel.
- Residential and Commercial BMP: Grass Replacement.
- Residential and Commercial BMP: Downspout Disconnect.
- Residential and Commercial BMP: Microirrigation.
- Onsite Water Conservation Survey.

These types of initiatives can also lead to measurable impacts. Specifically, initiatives which encourage water conservation allow for quantification if a simple number of variables are known, such as the number of Rain Barrels, and average annual rainfall.

4.1.6 MS4 Infrastructure (Ref 6)

The specific strategy initiatives for MS4 Infrastructure focus on improving the structural systems performance. The list of MS4 Infrastructure Strategies includes:

- Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.) for water quality improvement and for flood control risk management.
  - Optimize catch basin cleaning to maximize pollutant removal (4 times per year for metals and sediment TMDLs, elsewhere 1 per year).
  - Increased frequency of catch basin inspection and as-needed cleaning (Settlement Agreement).

  - Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.

- Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.
- Identify sewer leaks and areas for sewer pipe replacement prioritization.

Since these projects specifically focus on sub-surface activities, it is assumed that other benefits associated with changes above ground are not affected. Due to the specificity of these initiatives, it is reasonable to assume they will have a positive impact on local flood risk reduction, which in turn could potentially affect habitat related benefits, and possibly aesthetics.

4.1.7 Roads, Street, and Parking Lots (Ref 7)

These strategies specifically target street litter or debris will create aesthetic improvements. These strategies include:

- Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.
- Outreach to street sweeping enhancement-targeted areas.
- Enhance street sweeping through equipment replacement (replace every 4 years) and route optimization (sweep all areas twice a month).
- Initiate sweeping of medians on high-volume arterial roadways.
- Implement additional street sweeping near commercial routes adjacent to maintained MS4 channels..

The impact of these strategies can be quantified by estimating the volume of litter and street pollutants removed. Also, depending on the local land-use for the streets targeted, it is conceivable that a cleaner environment can lead to business development and investment. Jobs then would be supported by the money spent on operation and maintenance activities.

4.1.8 Pesticide, Herbicides, and Fertilizer BMP Program (Ref 8)

This category includes a broad initiative to reduce pollutant loads. The strategy entails:

- Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.

While there is too much uncertainty at this time to be able to assign specific measurable benefits, this reduction in pollutants entering the environment will benefit habitats, and aesthetics. It is assumed that overall public awareness and knowledge of the issue will increase.

4.1.9 Retrofit and Rehabilitation in Areas of Existing Development – Improve Structural Systems Performance (Ref 9)

The goal of this strategy is to improve existing systems, specifically:

- ❖ Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.

As this strategy focuses on retrofitting, is assumed to follow the same methodology for scoring other projects which increase the number of structural systems.

4.1.10 Retrofit and Rehabilitation in Areas of Existing Development – Increase the Number of Structural Systems (Ref 10)

This strategy was separated from the previous as it focuses on rehabbing existing ecological areas.

- ❖ Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.

Specific improvements in streams and other systems will improve habitats and aesthetics and can be measured using the area of each project.

4.1.11 Illicit Discharge, Detection, and Elimination (IDDE) Program (Ref 11)

This program is assumed to change behavior, specifically, reduce pollutants entering the environment through illegal discharges and disposal. The strategy is defined as:

- ❖ Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.

While broad strategies cannot be measured, it is assumed that the targeting of pollutants will improve the environment and benefit habitats and aesthetics. It is also assumed that overall public awareness and knowledge of the issue will increase.

4.1.12 Public Education and Participation: Initiatives to Change Behavior (Ref 12)

Strategies under Public Education and Participation are grouped under two categories, those which seek to change behavior, and are targeted at the community at large, and those which seek to reduce pollutants directly, by targeting business and industries. The strategies in this grouping target changing behavior, and are listed below:

- ❖ Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.
- ❖ Expand outreach to homeowners' association (HOA) common lands and HOA incentives.
- ❖ Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.
- ❖ Enhance and expand trash cleanups through community-based organizations involving target audiences.
- ❖ Improve consistency and content of websites to highlight enforceable conditions and reporting methods.
- ❖ Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.
- ❖ Enhance school and recreation-based education and outreach.
- ❖ Develop education and outreach to reduce over-irrigation.
- ❖ Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.

4.1.13 Public Education and Participation: Initiatives to Reduce Pollutants Directly (Ref 13)

These strategies differ from the previous group, it that they aim to reduce pollutants directly by targeting business and industries. This list includes:

- ❖ Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.
- ❖ Develop regional training for water-using mobile businesses.
- ❖ Promote and encourage implementation of designated BMPs in commercial and industrial areas.
- ❖ Outreach to impacted industry regarding minimum BMP requirement updates. Affects commercial, industrial, residential development.

While the total effect of the strategies cannot be determined at this time, it is assumed that the targeting of pollutants will improve the environment and benefit habitats and aesthetics.

The strategies which target commercial areas are assumed to effect more benefit categories, consistent benefit category scoring for other strategies which require minimum BMPs.

4.1.14 Enforcement Response Plan: Initiatives to Change Behavior (Ref 14)

The Enforcement Response Plan strategies can be categorized by 3 separate desired outcomes, and have been grouped separately. These strategies are focused at changing behavior.

It can be assumed that irrigation cost savings will occur as one strategy specifically targets over-irrigation. Where irrigation cost savings occur, there can potentially be emission savings. This is due to the reduced energy needed to provide the water, which in turn reduces the emissions generated from energy production. More information would be needed about these projects to determine the extent to which irrigation cost savings are realized.

List of Enforcement Response Plan Strategies to Change Behavior:

- ❖ Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.
- ❖ Increase enforcement of over-irrigation.

4.1.15 Enforcement Response Plan: Initiatives to Reduce Pollutants Directly (Ref 15)

This strategy differs from the previous, in that its outcome creates initiatives to reduce pollutants directly.

List of Enforcement Response Plan Strategies to Reduce Pollutants Directly:

- ❖ Increase enforcement associated with property-based inspections.
- ❖ Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.
- ❖ Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.
- ❖ Increase enforcement of water-using mobile businesses.

4.1.16 Enforcement Response Plan - Improve Structural Systems Performance (Ref 16)

This strategy in the Enforcement Response Plan is assumed to improve structural systems performance through minimum BMP enforcement, which is different from the targeted outcome of the other strategies:

- ❖ Increase enforcement of minimum BMPs for existing residential, commercial, and industrial development, including power washing.

As this strategy targets commercial and industrial areas, consistent benefit category scoring for other strategies which require minimum BMPs is used.

4.1.17 Additional Nonstructural Strategies- Reduce Pollutants Directly (Ref 17)

The remaining Nonstructural strategies related to pollutant reduction are grouped together, and separated from the additional strategies which improve structural systems performance. They are assumed to see habitat related benefits, but due to the broad nature and lack of specific details, that is the only benefit category affected. Additional outreach is assumed to provide Public Education benefits.

List of Additional Nonstructural Strategies which Reduce Pollutants Directly:

- Address and clean up pollutants from homeless encampments through Homeless Outreach Team
- Continue participating in source reduction initiatives
- Coordinate with other City of San Diego Departments to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available
- Pesticide Use Reduction
- Zinc Reduction Program
- San Dieguito Source Identification and Prioritization Process

4.1.18 Additional Nonstructural Strategies - Improve Structural Systems Performance (Ref 18)

These strategies differ from those which seek to reduce pollutants directly, as these target outcomes to improve structural systems and have specific tasks such as ‘actively monitor erosion’ are expected to positively impact habitat and flooding benefits. All the strategies which are research studies are assumed to provide public education benefits.

List of Additional Nonstructural Strategies which Improve Structural Systems Performance:

- Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property
- Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit
- Los Peñasquitos Watershed Special Study
- Reference watershed study
- Reference beach study

- ❖ Tecolote Creek Quantitative Microbial Risk Assessment (QMRA)
- ❖ Implement ASBS Compliance Plan
- ❖ Collaborate with City of San Diego PUD and other watershed stakeholders in the Lake Hodges Water Quality Concentration Study. Study will characterize conditions and identify sources.
- ❖ Develop and implement targeted roof replacement incentive program for Chollas

4.1.19 Green Infrastructure (Ref 19)

These strategies produce a large amount of quantifiable benefits due to the research that exists demonstrating the effectiveness of green infrastructure. This means that in most cases, at a minimum, the benefits can be measured. In certain cases, they can be monetized when enough information is available. As the specific strategies vary by watershed, a high level summary is provided.

Several BMPs involve increasing the total area (acres) of bioretention and permeable pavement on public parcels. Other strategies focus on specific target sites such as parks on green lots.

Strategies with specific design features (such as size of bioretention, etc.) allow for the ability to calculate the amount of storm water runoff retained, which can be used in to quantify Flood Risk Reduction, where applicable.

Less information is known about how these systems will fully operate, so it is possible that there could be irrigation cost savings, but such benefits cannot be accurately quantified without additional information. Where instances of irrigation cost savings could occur, some level of emission savings could also occur because of reduced energy use for delivering water.

Changes in biomass at a site (due to green streets plantings, or bioretention) can have quantifiable impacts on air quality and climate. The quantified amount depends on the specific properties of the new vegetation. Assuming that changes in biomass can be quantified, it is possible to suggest that noise reduction is a potential benefit, and local aesthetics would be improved. Local aesthetics would be quantified by the area of improved land.

An increase in biomass could reduce ambient temperatures, but the scale would be localized and small overall. Thus, we scored this other benefit category as ‘potential.’’

In instances where aesthetics are realized, business development can be quantified if enough information is available about the local characteristics of a green Infrastructure site (i.e., the proximity of the site to existing retail businesses).

Projects which provide pedestrian or bike access such as a green street or open space are assumed to provide quantifiable recreational benefits, such as additional miles of walkable or livable streets. The amount of these benefits will depend on data on size of the local population, the area of the site, and site usage.

4.1.20 Green Infrastructure: Green Streets (Ref 20)

Due to the information available regarding bioretention and the size of implementation, it can be assumed green streets will have the same scoring as the green infrastructure projects. As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve increasing the total area (acres) of green streets on specific avenues or subwatersheds.

4.1.21 Multiuse Treatment Areas: Infiltration and Detention Basins (Ref 21)

This section describes the process for scoring the structural strategies consisting of infiltration and detention basins.

It is assumed that the strategies for both golf courses involve similar wetland system projects, which are assumed to increase total biomass and provide entrainment and sequestration. If the total biomass change can be quantified, air and climate benefits can be measured and monetized.

While underground systems will be able to provide flood risk reduction, which in turn protects local habitats and ecological systems, any benefit categories that depend on changes in the above ground environment (such as habitat benefits) will not be affected, and are indicated as ‘Not Applicable.’ Projects that occur on public land, such as schools, provide the opportunity for educating the public or students about the strategy, and can be quantified by the number of people who learn about the strategy. These benefits depend on the number of students enrolled at the school, or the population of a neighboring community where public outreach about the project occurs.

Where instances of irrigation cost savings are thought to occur, emission savings could occur, but more information would be needed about these projects to determine the extent to which irrigation cost savings are realized.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve the installation of a subsurface detention galley on public parcels. Other options include dry detention systems, sediment basins, infiltration basins, and hyrdomodification BMPs.

4.1.22 Multiuse Treatment Areas: Stream, Channel and Habitat Rehabilitation Projects (Ref 22)

As these strategies target streams and other ecological areas, it is assumed habitats and aesthetics will improve, and can be measured using the area of the project. This strategy is assumed to be similar to the MS4 and Retrofit and Rehabilitation in Areas of Existing Development strategies.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve either wetlands or the Chollas Creek.

4.1.23 Water Quality Improvement BMPs: Proprietary BMPs (Ref 23)

Due to the nature of these projects, a basic assumption is the projects will improve water flow, and flood control and habitat benefits can occur. However, no other benefit categories can reasonably be expected to be impacted until more specific details about the sites and projects are known.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve drainage inserts on public parcels. Others involve hydrodynamic separation systems, dry-weather, or low flow diversions. Some are broader in nature, and provide direction on implementing a certain amount of acres of multiuse treatment area projects on private parcels and/or through public-private partnerships with various total storage sizes.

4.2 Optional Jurisdictional Strategies

This section provides a discussion of the methodology for assigning scoring categories to the Optional Jurisdictional Strategies, as well as sub-categories. Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." Many of these strategies are assumed to have a similar outcome and thus a similar other benefit category scoring as their Jurisdictional counterpart. The scores take into account the *potential* benefits that may occur, given the information available, and assumptions that are listed in each strategy. The scoring for these strategies is presented in Section 5, in Table 3 and Table 7. These strategies represent the latest consideration in an evolving process of identification, specification and assessment. Not all strategies have been implemented or have plans for immediate implementation. At the same time, the specification of the design standards also varies from strategy to strategy.

This list of individual strategies has been grouped according to the same categories that are contained in the Water Quality Improvement Plan and are presented in the same chronological order. The information found in the parenthesis next to the strategy group name (*Ref X*), refers to the number in the far left columns of Table 3 and Table 7.

4.2.1 Additional Nonstructural Strategies (Ref 24)

Many of these strategies are studies, which until they are completed, and the recommendations are implemented, cannot produce any benefits other than public education at the moment. Additionally, initiatives that involve participating or collaborating with other agencies or organizations are not applicable to other benefit categories at this time. The removal of invasive plants should protect existing habitats.

Additonal Nonstructural Strategies include:

Project	Location
Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	City-wide
Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for person experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	City-wide
Identify strategy resources and funding to support mapping and assessment of agricultural operations.	SDG above Lake Hodges
Coordinate with County of San Diego and identify resources and funding to implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	SDG
Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals.	City-wide
Conduct a feasibility study to test Permeable Friction Course (PFC), porous asphalt that overlays impermeable asphalt.	City-wide
As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	City-wide MB-Rose Canyon
Add permanent open spaces protections to underdeveloped city-owned land in and on the rim of Rose canyon and San Clemente Canyon.	MB, Rose Canyon
Forming a linear "park" from the southern end of Marian Bear Natural Park to the mouth of Rose Creek.	MB, Rose Canyon
Lake Hodges Natural Treatment System Project	SDG: Lake Hodges
If a regional collaboration is established for the Los Peñasquitos Lagoon, participate in restorative efforts in collaboration with TMDL Responsible Parties and TMDL responsible parties and other stakeholders.	Los Peñasquitos Lagoon Subwatershed
Participate in a watershed council or group and support the establishment of a watershed coordinator if one is established.	City-wide
Participate in a watershed council or group and support the establishment of a watershed coordinator if one is established. Includes participation in Rose Creek Watershed Team.	MB, Rose Canyon
Removal of invasive plants.	MB, Rose Canyon

4.2.2 Green Infrastructure – Optional Jurisdictional Strategies (Ref 25)

These strategies follow the same scoring as Jurisdictional Green Infrastructure projects. Under certain circumstances, these Green Infrastructure Strategies could be implemented.

4.2.3 Green Infrastructure: Green Streets – Optional Jurisdictional Strategies (Ref 26)

This strategy follows the same scoring as Jurisdictional Green Streets projects. Green Streets Strategies could be implemented if:

- ❖ If interim load reduction goals are not met and additional green infrastructure is required, the additional acreage of bioretention and permeable pavement can be implemented through green streets if potential opportunities for green infrastructure implementation on public parcels are not available.

4.2.4 Multiuse Treatment Areas: Infiltration and Detention Basins – Optional Jurisdictional Strategies (Ref 27)

These strategies follow the same scoring as Jurisdictional Multiuse Treatment Areas: Infiltration and Detention Basins projects.

4.2.5 Multiuse Treatment Areas: Stream, Channel, and Habitat Rehabilitation Projects – Optional Jurisdictional Strategies (Ref 28)

These strategies follow the same scoring as Jurisdictional Multiuse Treatment Areas: Stream, Channel, and Habitat Rehabilitation projects. List of Stream, Channel, and Habitat Rehabilitation Project includes:

- ❖ If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.
- ❖ Day lighting Cudahy Creek implementation.
- ❖ An example of this would be to lengthen the Genesee Avenue Bridge in Rose Canyon in order to eliminate the berm that bisects the riparian corridor. This would restore the natural riparian corridor and promote wildlife and recreational passage under Genesee.

4.2.6 Multiuse Treatment Areas: Other Opportunities – Optional Jurisdictional Strategies (Ref 29)

This strategy follows the same scoring as Jurisdictional Multiuse Treatment Areas: Other Opportunities projects. Other Opportunity Strategy is defined as:

- ❖ If interim load reduction goals are not met and additional multiuse treatment area projects are required, implement, as needed, on private parcels and/or through public-private partnerships.

4.2.7 Water Quality Improvement BMPs: Trash Segregation – Optional Jurisdictional Strategies (Ref 30)

These projects specifically target street litter or debris, and are assumed to create an aesthetic improvement, and can be quantified with estimates on the volume of litter removed. Depending on the local land-use for the streets targeted, business development could potentially increase. Jobs can also be supported by the money spent on operation and maintenance activities. Trash Segregation Strategies would be implemented under conditions defined as:

- ❖ If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.
- ❖ If interim load reduction goals are not met and additional proprietary projects are required, implement as needed.
- ❖ If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.

5 Results of Assessment

An overview of all the strategies, with the number of benefits, by benefit level, shown in descending order is presented in Table 2 and Table 3. Additionally, the total point value across the other benefit categories is presented in the far right column, with the header 'Total Point Value.' For example, green infrastructure has the greatest benefit score for both the jurisdictional and optional jurisdictional strategies. It is located at the top of Table 2, with a 'Total Point Value' of 7.3. This is calculated by:

- Multiplying the number of monetizable benefits (2), by their benefit scoring value (1);
- Multiplying the number of measurable benefits (3), by their benefit scoring value (0.667),
- Multiplying the number of potential benefits (10), by their benefit scoring value (0.333),
- Multiplying the number of not applicable benefits (0), by their benefit scoring value (0),
- Adding the subtotals together results in a total score of (2 + 2 + 3.3 + 0 = 7.3).

A detailed summary of the potential level of impact for each strategy and benefit category is presented in Table 6 and Table 7. For convenience, the number in the far left column, with the header 'Ref,' corresponds to the number next to the strategy group descriptions in the previous sections, and is consistent across all tables. Using Green Infrastructure as an example, the number in the first column of Table 2, (19) can be found in Table 6, and corresponds to the discussion of green infrastructure in the previous section, *Green Infrastructure (Ref 19)*

Table 2: Overview of Jurisdictional Strategies in Descending Order

Ref. [1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
19	Green Infrastructure	Structural	Green Infrastructure	2	3	10	0	7.33	15
20	Green Streets	Structural	Green Infrastructure	2	3	10	0	7.33	15
5	Commercial, Industrial, Municipal, and Residential Facilities and Areas[2]	Non-Structural	Initiatives to Change Behavior	0	5	6	4	5.33	11
21	Multiuse Treatment Areas - Infiltration and Detention Basins	Structural	Multiuse Treatment Areas	2	1	6	6	4.67	9
1	All Development Projects	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	14	1	4.67	14
2	Priority Development Projects (PDPs)	Non-Structural	Increase # Of Structural Systems	0	0	14	1	4.67	14
3	Construction Management	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
4	Commercial, Industrial, Municipal, and Residential Facilities and Areas[1]	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
9	Retrofit and Rehabilitation in Areas of Existing Development - Structures	Non-Structural	Increase # Of Structural Systems	0	0	14	1	4.67	14

Table 2: Overview of Jurisdictional Strategies in Descending Order (continued)

Ref. [1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
13	Public Education and Participation: Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	14	1	4.67	14
15	Enforcement Response Plan: Improve Structural Systems Performance	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
22	Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects	Structural	Multiuse Treatment Areas	0	2	8	5	4.00	10
14	Enforcement Response Plan: Initiatives to Change Behavior	Non-Structural	Initiatives to Change Behavior	0	1	6	8	2.67	7
10	Retrofit and Rehabilitation in Areas of Existing Development	Non-Structural	Improve Structural Systems Performance	0	2	3	10	2.33	5
16	Enforcement Response Plan: Initiatives to Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	2	3	10	2.33	4
12	Public Education and Participation: Initiatives to Change Behavior	Non-Structural	Initiatives to Change Behavior	0	1	4	10	2.00	4
11	Illicit Discharge, Detection, and Elimination (IDDE) Program	Non-Structural	Initiatives to Change Behavior	0	1	3	11	1.67	4
7	Roads, Street, and Parking Lots - Cleaning Maintaining, etc	Non-Structural	Improve Structural Systems Performance	0	1	2	12	1.33	3

Table 2: Overview of Jurisdictional Strategies in Descending Order (continued)

Ref. [1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
8	Pesticide, Herbicides, and Fertilizer BMP Program	Non-Structural	Initiatives to Reduce Pollutants Directly	0	1	2	12	1.33	3
6	MS4 Infrastructure	Non-Structural	Improve Structural Systems Performance	0	0	3	12	1.00	3
18	Additional Nonstructural Strategies: Improve Structural Systems Performance	Non-Structural	Improve Structural Systems Performance	0	0	3	12	1.00	3
17	Additional Nonstructural Strategies: Initiatives to Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	2	13	0.67	2
23	Water Quality Improvement BMPs - Proprietary BMPs	Structural	Water Quality Improvement	0	0	2	13	0.67	2

1. The reference number refers to strategy groups presented in pages 9-28.

Table 3: Overview of Optional Jurisdictional Strategies by Descending Order

Ref.[1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable
25	Green Infrastructure – Optional Strategies	Structural	Green Infrastructure	2	3	10	0	7.33	15
26	Green Streets – Optional Strategies	Structural	Green Infrastructure	2	3	10	0	7.33	15
27	Multiuse Treatment Areas-Infiltration and Detention Basins – Optional Strategies	Structural	Multiuse Treatment Areas	2	1	6	6	4.67	9
28	Multiuse Treatment Areas-Stream, Channel and Habitat Rehabilitation Projects – Optional Jurisdictional Strategies	Structural	Multiuse Treatment Areas	0	2	8	5	4.00	9
29	Multiuse Treatment Areas- Other Opportunities – Optional Strategies	Structural	Multiuse Treatment Areas	0	1	8	6	3.33	9
30	Water Quality Improvement BMPs-Trash Segregation – Optional Strategies	Structural	Water Quality Improvement	0	0	3	12	1.00	2
24	Additional Nonstructural Strategies – Optional Jurisdictional Strategies	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	2	13	0.67	2

1. The reference number refers to strategy groups presented in pages 9-29.

In Table 6 and Table 7, a detailed summary of the potential level of impact for each strategy and benefit category is presented. For these tables, a key to symbols and point value is presented for each level of impact in Table 4. In some cases, the strategy group includes individual strategies that are classified by different types of strategy outcomes. Table 5 shows the numerical key used in Table 6 and Table 7. To make the evaluation process more transparent, a discussion about the assumptions and rationale for the assignment of a benefit category level to a specific strategy is briefly discussed for each type of Water Quality Improvement Plan strategy following the summary tables. The reference for the discussion below for each strategy is listed in column 1 of Table 6 and Table 7. In addition to presenting point values, the total number of potentially applicable benefits is also shown.

Table 4: Key to Symbols

Symbol	Level of Impact	Point Value
●	Monetizable	1
⦿	Measurable	0.67
○	Potential	0.33
⊗	Not Applicable	0

Table 5 provides a key to the number in the column with the header 'Strategy Outcome.' For example, the first strategy group listed, All Development Projects, has the number 6 in the 'Strategy Outcome' column. The number 6 in Table 5 indicates that All Development Projects are Nonstructural Strategies comprised of Initiatives to Reduce Pollutants Directly.

Table 5: Key to Strategy Outcome

ID	Category of Strategy	Type of Strategy Outcome
1	Structural	Green Infrastructure
2	Structural	Multi Use Treatment
3	Structural	Water Quality Improvement
4	Nonstructural	Improve Structural Systems Performance
5	Nonstructural	Increase the Number of Structural Systems
6	Nonstructural	Initiatives to Reduce Pollutants Directly
7	Nonstructural	Initiatives to Change Behavior

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
1	**All Development Projects**	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**
2	**Priority Development Projects (PDPs)**	5	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**
3	**Construction Management**	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**
4	**Commercial, Industrial, Municipal, and Residential Facilities and Areas**	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
5	**Commercial, Industrial, Municipal, and Residential Facilities and Areas**	7	◉ [0.67]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	◉ [0.67]	◉ [0.67]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	○ [0.33]	**5.3**	**11**
6	**MS4 Infrastructure**	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	**1.0**	**3**
7	**Roads, Street, and Parking Lots**	4	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	**1.3**	**3**
8	**Pesticide, Herbicides, and Fertilizer BMP Program**	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	**1.3**	**3**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	**Strategy Group**	**Strategy Outcome[2]**	**Water Cost Savings**	**Energy Cost Savings**	**Flood Risk Reduction**	**Air Particulate Entrainment**	**Climate Impacts**	**Habitat Related Benefits**	**Air Quality Emission Reduction**	**GHG Emission Reduction**	**Property Value Enhancement**	**Recreational Benefits**	**Business Development & Jobs**	**Crime Reduction**	**Public Education/ Environmental Stewardship**	**Noise Reduction**	**Heat Island Effect**	**Total Point Value**	**Number of Applicable Benefits**
9	**Retrofit and Rehabilitation in Areas of Existing Development - Improve Structural Systems Performance**	5	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**
10	**Retrofit and Rehabilitation in Areas of Existing Development - Increase the Number of Structural Systems**	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	◉ [0.67]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**2.3**	**5**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
11	Illicit Discharge, Detection, and Elimination (IDDE) Program	7	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	1.7	4
12	Public Education and Participation: Initiatives to Change Behavior	7	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	2.0	4

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
13	**Public Education and Participation: Initiatives to Reduce Pollutants Directly**	6	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**
14	**Enforcement Response Plan: Initiatives to Change Behavior**	7	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	**2.7**	**9**
15	**Enforcement Response Plan: Improve Structural Systems Performance**	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**4.7**	**14**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
16	**Enforcement Response Plan: Initiatives to Reduce Pollutants Directly**	6	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	**2.3**	**4**
17	**Additional Nonstructural Strategies: Initiatives to Reduce Pollutants Directly**	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**0.7**	**2**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
18	**Additional Nonstructural Strategies: Improve Structural Systems Performance**	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**1.0**	**3**
19	**Green Infrastructure**	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**7.3**	**15**
20	**Green Streets**	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**7.3**	**15**

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
21	**Multiuse Treatment Areas - Infiltration and Detention Basins**	2	○ [0.33]	○ [0.33]	○ [0.33]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	**4.7**	**9**
22	**Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects**	2	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**4.0**	**10**
23	**Water Quality Improvement BMPs**	3	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	**0.7**	**2**

1. The reference number refers to strategy groups presented in pages 9-29.
2. Strategy Outcome as described in Table 5.

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan - Optional Jurisdictional Strategies

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
24	**Additional Nonstructural Strategies**	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**0.7**	**2**
25	**Green Infrastructure**	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**7.3**	**15**
26	**Green Streets**	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	**7.3**	**15**

Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan - Optional Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	**Strategy Group**	**Strategy Outcome[2]**	**Water Cost Savings**	**Energy Cost Savings**	**Flood Risk Reduction**	**Air Particulate Entrainment**	**Climate Impacts**	**Habitat Related Benefits**	**Air Quality Emission Reduction**	**GHG Emission Reduction**	**Property Value Enhancement**	**Recreational Benefits**	**Business Development & Jobs**	**Crime Reduction**	**Public Education/ Environmental Stewardship**	**Noise Reduction**	**Heat Island Effect**	**Total Point Value**	**Number of Applicable Benefits**
27	**Multiuse Treatment Areas - Infiltration and Detention Basins**	2	○ [0.33]	○ [0.33]	○ [0.33]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊙ [0.67]	⊗ [0]	⊗ [0]	**4.7**	**9**
28	**Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects**	2	○ [0.33]	○ [0.33]	⊙ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊙ [0.67]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**4.0**	**9**
29	**Multiuse Treatment Areas - Other Opportunities**	2	○ [0.33]	○ [0.33]	⊙ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**3.3**	**9**

Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan - Optional Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	**Strategy Group**	**Strategy Outcome[2]**	**Water Cost Savings**	**Energy Cost Savings**	**Flood Risk Reduction**	**Air Particulate Entrainment**	**Climate Impacts**	**Habitat Related Benefits**	**Air Quality Emission Reduction**	**GHG Emission Reduction**	**Property Value Enhancement**	**Recreational Benefits**	**Business Development & Jobs**	**Crime Reduction**	**Public Education/ Environmental Stewardship**	**Noise Reduction**	**Heat Island Effect**	**Total Point Value**	**Number of Applicable Benefits**
30	**Water Quality Improvement BMPs - Trash Segregation**	3	⊗ [0]	⊗ [0]	O [0.33]	⊗ [0]	⊗ [0]	O [0.33]	⊗ [0]	⊗ [0]	O [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	**1.0**	**2**

1. The reference number refers to strategy groups presented in pages 9-29.
2. Strategy Outcome as described in Table 5.

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Appendix 1: Sustainable Return on Investment Assessment of Water Quality Improvement Strategies. Draft Report. June 2014

Note to reader: This appendix is a re-print of the Phase 1 Draft Report from this project. Some aspects of the strategies and framework differ from what is included in the main report. The literature review in the following Phase 1 report provides a foundation for all subsequent analysis.

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Sustainable Return on Investment Assessment of Water Quality Improvement Strategies

Draft Report

June 2014

Prepared for:

City of San Diego, Storm Water Division

Prepared by:

HDR Engineering, Inc.
100 Oceangate, Ste. 1120
Long Beach, CA 90802

Executive Summary

The aim of this project is to help the City of San Diego Storm Water Division account for the costs and benefits of storm water management strategies. Benefits (sometimes called "co-benefits") include a variety of outcomes beyond improved water quality that some storm water strategies may achieve. The Division has identified a range of structural best management practices (BMPs (e.g., a constructed runoff reduction system such as a bio-swale), and nonstructural BMP activities (i.e. programs that promote installations of constructed systems, or reduce pollutants directly through education and outreach, for example). The Division now seeks to incorporate information on benefits of strategies into a prioritization approach so that as the Division selects strategies to meet its regulatory requirements, it is generating the best value for the community and local businesses.

This report summarizes the findings of a literature review on storm water management benefits and costs and a programmatic assessment of the Division's strategies and associated benefits. The purpose of the assessment is to determine which types of benefits, beyond water quality improvements, might arise from the Division's different storm water management strategies and to determine if and how these benefits can be quantified, and included in a decision making framework.

Our findings in this report indicate that many types of benefits can accrue to local residents, businesses, and the general public. Common types of benefits that have been evaluated in a number of cities around the U.S. include flood risk reduction, reduced energy consumption (and associated air quality emissions), and improved aesthetics. Computing benefits of BMPs has been standardized to some extent in the Center for Neighborhood Technology (CNT) report which outlines the data and calculations for a number of benefits (CNT, 2010). For the Division, a similar calculation process could be implemented and it would be consistent with efforts implemented in other cities. However, a significant level of uncertainty would arise in preparing such estimates without specific data on BMP designs and activities for each strategy as well as site specific information about where they would be implemented.

The City developed several dozen storm water management strategies ranging from types of structural BMPs to projects designed to affect public or municipal employee polluting behavior. Some of the strategies listed are assessment projects that provide information necessary to make decisions or to implement a subsequent non-structural strategy. To initiate this study, we grouped the strategies into specific categories:

- Structural
    - Green Infrastructure
    - Multiuse Treatment Areas
    - Water Quality Improvements

- Non Structural
    - Results in increases in the number of structural systems
    - Results in improved performance of existing structural systems
    - Results in changes in behavior that reduced pollutant loads
    - Results in direct removal of pollutants from watersheds

The next best evaluation strategy for the Division at present would entail a simplified assessment of the likely *existence* of quantifiable net benefits for each strategy. In this report, we have evaluated the degree to which benefits can be quantified (and potentially monetized) for each type of strategy. A net result of benefits exceeding negative attributes has been qualitatively assessed based on findings in the literature. This is not to say that the benefit would be greater than implementation costs, but that co-benefits would likely exceed negative impacts to the community of implementing the strategy.

The results of this assessment are shown in Table 1. A “Yes” in one of the table cells indicates that there would be sufficient evidence to quantifiably determine the value of a strategy, provided that information about the strategy and implementation location is better understood. In this high-level summary, it may be assumed that if a quantifiable benefit exists, they would be large enough to generate observable public value and influence decisions accordingly.

These initial findings however must be developed in more detail to provide practical use in prioritizing strategies for the Division. In particular, the feasibility of estimating benefits must assessed for each individually identified strategy (see Appendix 2), not its strategy group as shown in Table 1. With this information, the Division can establish an initial indication of specific strategies that provide the best value. This effort is planned for phase two of this project.

Table 1: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies

Strategy	Structural			Nonstructural			
	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives To Change Behavior	Initiatives To Reduce Pollutants Directly
Flood Control	YES	YES	YES	YES	YES	YES	
Irrigation Cost Savings	YES			YES	YES	YES	
Energy Cost Savings	YES			YES		YES	YES
Air Particulate Entrainment	YES			YES		YES	YES
Climate Impacts	YES			YES		YES	YES
Habitat Related Benefits							
Air Quality Emission Reduction	YES			YES		YES	YES
GHG Emission Reduction	YES			YES		YES	YES
Heat Island Effect	YES	YES		YES	YES	YES	
Aesthetics	YES	YES		YES	YES	YES	YES
Recreational Benefits	YES	YES		YES	YES	YES	YES
Noise Reduction							
Business Development & Jobs	YES			YES	YES	YES	YES

Crime Reduction		
Public Education/ Environmental Stewardship		

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Acronyms

BCA – Benefit Cost Analysis
BES – Bureau of Environmental Services
BMP – Best Management Practice
Btu – British Thermal Unit

CAMX - California-Mexico Power Area
CEA – Cost-Effectiveness Analysis
CLRP – Comprehensive Load Reduction Plans
CNT – Center for Neighborhood Technology
CO2 – Carbon Dioxide
CSO – Combined Sewer Overflow

DOT – Department of Transportation

EIA – Economic Impact Analysis
EPA –Environmental Protection Agency

IDDE – Illicit Discharge, Detection, and Elimination

kWh – Kilowatt Hour

LACDPW – Los Angeles County Department of Public Works
LID – Low Impact Development

MMSD – Milwaukee Metropolitan Sewage District
MODA – Multi-Objective Decision Analysis
M Wh – Mega Watt Hour

NRDC – Natural Resources Defense Council
NOx - Nitric oxide and nitrogen dioxide
NPV – Net Present Value

O3 – Oxide

PFC – Permeable Friction Course
PM – Particulate Matter
PWD – Philadelphia Water District

SO2 – Sulfur Dioxide
SPU – Seattle Public Utilities
SROI – Sustainable Return on Investment

TBL – Triple Bottom Line
TIGER – Transportation Investment Generating Economic Recovery
TMDL – Total Maximum Daily Load

UTC – Urban Tree Canopy

WAMP – Watershed Asset Management Plan
WERF – Water Environment Research Foundation
WQIP – Water Quality Improvement Plan

1 Introduction

The City of San Diego Storm Water Division (Division) seeks a framework for prioritizing storm water management strategies that have been identified as part of the Water Quality Improvement Plans for each watershed. These strategies include a range of best management practices (BMPs) in structural systems (i.e., a constructed runoff reduction system, such as a bio-swale), and nonstructural activities (i.e. programs that promote installations of constructed systems, or reduce pollutants directly through education and outreach, for example). Each of the identified strategies is intended to contribute to meeting Total Maximum Daily Load (TMDL) regulatory requirements.

At the same time, each strategy can also provide *additional* benefits (sometimes called "Co-benefits") to the community. Depending on the type of strategy, such benefits can include flood risk reduction, reduced energy consumption and associated air quality emissions, improved aesthetics and habitat creation. Of course, not all BMPs generate positive benefits – property damage can occur if infiltration systems are poorly performing or additional street sweeping miles would increase air pollution costs. [3] Whatever the case, accounting for such benefits is challenging because each one is measured in different units and data is rarely available to quantify existing conditions and predicting changed conditions. Even so, estimating benefits can contribute to decision making. WERF (2014) notes that while a number of studies have shown storm water BMPs to be cost-effective and efficient at achieving water quality goals, traditional engineering costing methods fail to adequately value the multiple benefits and improved life-cycle costs that storm water BMPs provide.

The Division has contracted HDR to apply its *Sustainable Return on Investment (SROI)* process to develop a sound prioritization framework that accounts for storm water management benefits. SROI is an economics-based approach to evaluating and communicating the economic benefits and expenditure-based impacts across a *triple bottom line* – the financial, environmental and societal outcomes of a project. The process includes: (a) transparent review of evidence; (b) economic framework for evaluation; (c) workshop-based discussion of evidence; and (d) accounting for risk and uncertainty in key drivers of outcomes. SROI is a proven process, having been implemented in billions of dollars in capital projects over the last 8 years. In this project, we apply SROI to evaluate key economic benefits and use this to develop a sound framework for prioritizing strategies.

This document discusses our initial tasks in this effort. We report on findings from a literature review for substantiating the existence of such benefits, and an evaluation of strategies, to assess how different benefit categories may apply. We also discuss an initial assessment of the applicability of different types of benefits for individual BMP strategies. In addition, we report on an introductory workshop with stakeholders on the concept of storm water management benefits and frameworks to include estimated benefits in

[3] To make the discussion more concise, "Benefits" refer to both positive and negative outcomes.

decision making. In addition, this phase will also determine the methods to account for co-benefits in qualitative, quantitative or monetized metrics.

2 Literature Review on Storm water Management Benefits

Conceptual frameworks and empirical evidence on economic benefits of storm water management have been developed in a number of studies. This chapter characterizes this evidence to establish a foundation for understanding the types of benefits from storm water management that are included in project evaluations in a SROI process. The findings of this literature also indicate that the estimation of benefits beyond water quality improvements is an emerging field. The potential for life cycle cost savings of green infrastructure in suitable locations has been fairly well established. Yet, it has been more difficult to establish standards for estimating the benefits from other aspects of BMPs that affect environmental and societal outcomes. Significant uncertainties remain over the degree to which a BMP can generate tangible benefits. In most cases, benefits depend largely on the design and site conditions.

2.1 What are Economic Benefits and Impacts?

Economic benefits are the fundamental measure of a project's overall worth to society.[4] Storm water management benefits,[5] whether they relate to avoided flood damage, improved air quality, or energy cost savings are evaluated in the same theoretical framework. Economic researchers assess the value for products and services from data on people's expenditures and their preferences for goods that are not sold (e.g. air quality).[6] Research can provide a basis for understanding how people value storm water benefits in terms of financial, environmental and societal benefits. Moreover, this evidence can support agency staff in developing strategies to manage environmental investments to maximize environmental benefits per dollar spent (WERF, 2014, Ecosystem Valuation, 2007).

A complementary measure of the worthiness of a project reflects the expenditures to build and maintain it. These expenditures and their connection to the broader economy are

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[4] Benefits are a somewhat esoteric theoretical economic construct of how people value a product or service. The benefit of a product or service is derived from the premise that some people gain greater *value* from the use of a product or service, especially its initial use, than the price they paid for it. For example, the first glass of water to a thirsty person would be much more highly valued and than the last one consumed, even if the price is the same for each glass. It is further assumed that they would be *willing to pay* some amount to gain that value from it, even if it is above the market price. The idea that a person's willingness to pay can be greater than a market price is a fundamental principal of the value gained by consumers.

[5] In standard economic terminology, benefits can be *positive* or *negative* depending on whether they are desirable or undesirable. A negative storm water management benefit can arise if flood control measures that entail infiltration cause damage to neighboring properties.

[6] Goods that are not sold in markets, such as the recreational value from natural areas, can be derived from the expenditures of persons who visit these areas, or the responses of people to responses to structured surveys which to determine a willingness to pay for the hypothetical avoidance of some undesirable impact to such areas.

defined as *economic impacts*. The expenditures on materials, labor, land, and monitoring over the project lifecycle are implementation costs that are measureable and tangible. Economic impacts of storm water management spending are straightforward to estimate since expenditures are readily estimable and the wider economic impacts can be assessed using economic impact multipliers. Results from economic impact analysis, such as the numbers of jobs created from storm water management strategies reflect the impact on the overall economy and can be estimated at the local, regional and even national levels.

2.2 What are the Key Economic Benefits of Storm water Management?

A growing number of researchers have evaluated the economic benefits and impacts of storm water BMPs in addition to cost savings (See: EPA, 2013; WERF, 2014; and CNT, 2010). Some of the most commonly cited benefits stem from the functional ability of BMPs to reduce the risk of flood damage, costs of public infrastructure, and pollution and water treatment costs. EPA (2013) research on case studies of economic benefits of low impact development and green infrastructure revealed that a number of benefits can be characterized along the triple bottom line (Table 2).

Table 2: Examples of Potential Benefits from Green Infrastructure

Environmental benefits	Financial benefits	Societal benefits
Improved water quality	Reduced construction costs relative to grey infrastructure	Improved aesthetics
Improved air quality from trees	Reduced scale of grey infrastructure design	More urban greenways
Improved ground water recharge	–	Increase in public awareness of storm water management
Energy savings from reduced air conditioning	–	Reduced flash flooding
Reduced greenhouse gas emissions	–	Green jobs
Reduced urban heat stress	–	Increase in economic development from improved aesthetics
Reduced sewer overflow		

Source: EPA (2013)

Estimating benefits however can be challenging because of a lack of data on the physical changes and value of such changes. Data gaps can arise for either or both existing site conditions (prior to project implementation) or predicted changes in conditions (after implementation). In all cases, data must be collected at a specific site and project to develop credible benefit estimates. Where data gaps exist, analytical decisions can be made with respect to evaluating some types of benefits in qualitative terms (such as multi-objective decision analyses) or by quantifying uncertainty (using Monte Carlo simulation).

Several categories of benefits have been identified and described in published literature on storm water management benefits. This section reports on results from a literature review that focused on defining benefit categories and describing the conditions when it can arise. More detail on values and calculation methods are discussed in the Appendix 1. To facilitate the understanding of benefits, several groups of benefit categories are defined including: runoff retention/ detention, energy cost savings, air quality improvements, ecosystem services, and community livability. The categories of benefits in each of these groups are described below.

2.2.1 Runoff Retention / Detention Benefits

Several types of green infrastructure (e.g. green roofs, bio-retention, permeable pavement, rain barrels, etc.) are designed to detain, retain and/or infiltrate rain where it falls. Corresponding reductions in storm water runoff lower the total and peak volumes in the storm water system. Benefits of runoff retention / detention include a reduction in downstream flood risk to properties, and reduced irrigation costs for property owners, that is, if the retention systems can supplement irrigation needs. Another potential benefit includes any reduction in erosion in streams and corresponding habitat impacts, but this are rarely evaluated due to data limitations. The effectiveness of green infrastructure in reducing runoff and generating benefits is determined by several factors including local precipitation characteristics, design capacity and maintenance practices over its functional lifespan.

Flood Risk Reduction: Reduced runoff can reduce the frequency and severity of flooding in neighborhoods that are particularly susceptible to it. The effectiveness of green infrastructure on flooding depends on the design capacity and rainfall conditions, scale of implementation across a watershed, soil characteristics (for systems that facilitate infiltration), and watershed characteristics.[7] In addition, if the storm sewers are connected to combined sewer systems, the reduced volume can generate operational cost savings at the wastewater treatment plant.[8] The value of flood control is estimated as a reduction in property damage if flooding occurs.

Irrigation Cost Savings: On-site water retention in rain barrels or other similar systems can supplement irrigation needs in yards and gardens. Available captured water can generate an added benefit of reducing potable demand for irrigation and associated costs for owners. Key drivers of the life cycle cost savings for these systems include local rainfall characteristics (e.g. frequency and depth), storage capacity and water rates. The extent to which these systems can generate irrigation cost savings above installation costs (maintenance costs are often low), depends on the demand for irrigation and ability to meet this demand with stored water. For property owners, supplemental irrigation directly reduces the volumes demanded from public sources and its costs. From a utility and public perspective, reductions in water volumes

[7] Kane County, IL and Lenexa, KS evaluated flood control benefits of future land development scenarios (EPA, 2013). However, because these benefits are site-specific, the results cannot be generalized to other sites.

[8] Wastewater treatment operational cost savings, in the context of combined sewer systems, include reductions in: (a) treatment costs; (b) air pollution emissions; and (c) greenhouse gas emissions (CNT, 2010).

demanded translate into lower levels of energy consumed for water treatment, which in turn reduces air contamination and greenhouse gas emissions (these benefits are discussed in Section 2.2.3).

2.2.2 Energy Cost Savings Benefits

Several aspects of green infrastructure can lower energy use and generate cost savings. For instance, green roofs and trees can change the gain or loss of energy in buildings, and in turn decrease costs for heating or cooling (NRDC, 2013).[9] These benefits are influenced by several site and design factors and accrue directly to property owners.

Energy Cost Savings: Site-specific research has shown that the shade that trees provide adjacent buildings and the additional insulation of green roofs on buildings can lower the heating and cooling energy costs in buildings. Of course, the effectiveness of these BMPs in lowering energy use depends on many factors including the BMP design, type of plant material, building characteristics, and climate conditions (CNT, 2010). In addition, for trees, the benefits would not be realized for several years until they have reached a height and width that provides noticeable shading. In another example, green roofs and other storage systems have been installed at water utilities and have provided a supplemental water source that has reduced energy and operational costs for pumping (EPA, 2013).[10] These costs savings would constitute a benefit directly for the utility, and by extension to its rate-payers.

2.2.3 Emissions Reduction Benefits

Generation of electricity is reduced when green infrastructure (e.g. green roofs or trees) reduces energy demand in buildings, or when water harvesting reduces energy demand at treatment plants. Reductions in electricity demand means that some amount of burning fossil fuels is avoided. As a result, there would be a reduction in the harmful emissions of criteria air contaminants (e.g. NOx, SOx, PM, etc.) and greenhouse gas emissions. The U.S. electrical grid enables energy to flow from a large interconnected network and makes it nearly impossible to link a specific source of generation with a particular use. Still, it is possible to generalize over the types of energy consumed in a State and to use this information to characterize how a reduction in energy consumption leads to a reduction in pollution. The benefit of emissions reduction is then estimated using established economic valuation standards.

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[9] These cost savings are additive to air pollution emissions savings from avoided energy generation (EPA, 2013).

[10] The L.A. County Department of Public Works in its Sun Valley Watershed Management Plan accounted for decreased energy demand for pumping water because the harvested and infiltrated water provide supplemental supplies. (EPA, 2013)

Air Pollution Emission Reduction: The total amount of reduction in criteria air contaminant emissions from a power plant is directly tied to the reduction in energy use in a specific location. Energy savings are readily converted to its emission rate reductions by utilizing data from EPA and other public sources. The economic value of lower air pollutants is inferred from its impact on human health and lower medical costs. The reduction of each type of criteria air contaminant has a different economic benefit value per ton. Evidence of the conversion of a reduction in emissions to economic benefits relies on published economic research and from Federal regulatory rule-making, in which values are ultimately approved by the US Office of Management and Budget.[11]

Greenhouse Gas Emission Reduction: Similar to criteria air contaminants, greenhouse gas emissions from energy generation also cause economic damages. The tons of greenhouse gas emissions are computed from the same data sources as criteria air contaminants. The value of lower greenhouse gas emissions is linked to a reduction in in long-term damage to the global economy. While the Federal government provides guidelines on the value per ton of greenhouse gas emission reduction, other agencies have used different values. For example, the Portland Bureau of monetized this reduction in carbon emissions due to cooling and heat savings in buildings with Ecoroofs (EPA, 2013).

2.2.4 Ecosystem Service Benefits

Green infrastructure such as green roofs, bio-swales and trees can also provide a number of additional environmental and ecosystem services. These include entrainment of air particulates, carbon sequestration and habitat creation. Each of these benefit categories is directly related to the plant material that is installed as part of the green infrastructure system. Accrual of benefits depends on a variety of design and site conditions though research is available to quantify some of the physical performance measures of green infrastructure. Estimation of economic benefits at a new site would in most cases require new research at that site since limited information has been broadly developed.

Air Particle Entrainment: Some green infrastructure systems have the ability to uptake pollutants directly from the environment, which reduces adverse human health impacts. The criteria air contaminant pollutants that can be entrained include nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter classifies as PM10.[12] Key drivers of these benefits include the amount (in square footage, or number of trees) of green infrastructure, as well as the current levels of criteria pollutants, and size of the local population, especially those whose health is more vulnerable to environmental conditions. The quantified amount of pollutants

[11] Many economic values originally come from regulatory rule-making in which an economic analysis is reviewed and ultimately accepted by the Office of Management and Budget before the rule becomes a law.

[12] The Charlotte-Mecklenburg Storm Water Services, serving an area of 526 square miles, included these entrainment benefits when analyzing their reforestation in their LID/GI approach, as it is relatively inexpensive but offers large benefits in terms of air quality and storm water management, the county has simply committed to making reforestation a priority (EPA, 2103)

entrained can be monetized using the same economic values per ton that are applied in the air pollution emission reduction calculations.

Carbon Sequestration: Carbon sequestration is the process of storing carbon in biomass and soils as atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis. The amount that can be sequestered is dependent on the above ground biomass of the tree, green roof or bio-swale. Sequestration benefits only last as long as the plants or trees are alive and that they vary with the age of the vegetation. Carbon sequestration rates depend on the type of species and location where it is grown (Pepper, 2012). Carbon sequestration in green roofs can have high variability due to roof age and substrate depth.[13] Other factors that affect carbon sequestration in green roofs are geographic region, plant species and roof management or maintenance (Getter, K. L. et al., 2009; Wise, S. et al., 2010; City of Portland BES, 2010; CNT, 2010). In addition, healthy and large trees can store about 1000 times more carbon than smaller trees and if those trees have a long lifespan they also tend to be the biggest contributor to carbon removal (Nowak, D. J. & Crane, D. E., 2001; Escobedo, et. al. 2012; McPherson, E. G. et al., 2007; CNT, 2010). The value of carbon sequestration is estimated with the same benefit parameters as with greenhouse gas emissions.

Habitat Related Benefits: Green roofs, rain gardens and other vegetated infiltration systems can improve the habitat for flora and fauna, such as bird and insect species. These different types of habitats are usually small in size and have limited impacts. But, it is conceivable that greater benefits may arise from large-scale strategies that are connected to habitat corridors. Limited research is available to directly assess the economic value of habitat creation. As a first step, a biological survey would be required to assess current conditions and to evaluate potential changes in flora and fauna habitat and other ecosystem services. Valuation of these changes though would remain difficult because of a lack of economic research on the benefits of small scale habitats. Potential proxy values may be drawn from wetland valuation research for some types of green infrastructure, but developing accurate estimates would be highly uncertain. Still, in some studies such as the benefit cost analysis in Ann Arbor, the value of habitat creation is estimated (ECONorthwest, 2011).

[13] One study indicated that three roofs with similar substrate depth had increased carbon with age of the roof and vegetation. Data from another study showed green roofs stored, on average, between 60 to 240 grams of carbon per square meter in the aboveground plant and between 30 and 185 g C·m-2 in belowground biomass.

2.2.5 Community Livability Benefits

A series of quantifiable and qualitative benefits also enhance the quality of life across a community. Emerging research on these benefits stems in part from the ways in which *social capital* forms and grows in a community. For example, the Portland Bureau of Environmental Services writes "social capital is the benefits that individuals and communities derive from having social contacts and networks throughout their communities and is based on the notion that individuals who interact with each other will support each other to the benefit of the entire community" (Portland BES, 2010). Green infrastructure, and especially ones that encourage use of the outdoors, can help induce interactions and connections across the community. This includes the personal value of health and recreation, as well as an improvement in the level of investment in business district.

Reduced Health Effects - Heat Island Related Impacts: The term "heat island" describes a landscape characteristic in which cities tend to be hotter than nearby rural areas.[14] These hotter temperatures come from the radiant heat off of impervious surfaces and buildings, and a lack of plant material to produce evapotranspiration that cools the air (EPA, 2008; Grimmond, C. et al., 2010; Wise, S. et al., 2010; Burden, D., 2006; City of Portland Bureau of Environmental Services, 2010; Grimmond, C. et al., 2010; and Stratus Consulting Inc., 2009). Across a city, higher temperatures can lead to adverse health effects on people (e.g. respiratory difficulties, exhaustion, heat stroke and heat-related mortality), particularly older and more vulnerable populations.[15] Green infrastructure can reduce temperatures and lead to lower health effects if implemented widely across a city. Urban trees, for example, emit low volatile organic compounds (VOC), and reduce air temperatures through transpiration. Research has shown that trees can reduce local temperatures up to 8.7°F compared to impervious surfaces. In Chicago, a study showed substantial differences in roof surface temperatures between green and conventional coverings. The effect of green infrastructure on mitigating heat island effects depends on wide scale implementation (Stratus, 2009). Data on the demographics of an area also influence related benefits because certain age cohorts are more susceptible to heat related illnesses than others.

Aesthetic Improvements: Some strategies improve the overall visual appearance of a community simply by having planted material among impervious surfaces. In addition, some BMPs strategies aim to directly reduce litter or debris from public spaces to make it more visually appealing. These aesthetic improvements are difficult to estimate directly but can be observed in differences in the prices on properties which are in the vicinity of aesthetically attractive areas. To estimate benefits of these improvements, property value studies are conducted to isolate only a small portion of price differences that relate to being near the green

[14] http://www.epa.gov/heatisland/index.htm

[15] The heat island mitigation to lowering emission levels of air pollutants and greenhouse gases through the reduced energy demand (via greater air conditioning needs) and lower demand for outdoor irrigation needs. These effects, if they can be quantified, are discussed above.

infrastructure installation. A number of researchers have evaluated such property value differences and used them in BCAs. For example, the Alachua County Environmental Protection Department and Public Works Department (in Florida) examined the changed in property values due to the county's green infrastructure programs and found that the increase in land values for properties adjacent to some measures (EPA, 2103). The application of findings from one site to another is not always straightforward and depends on site specific conditions.

Recreational Benefits: In addition to providing a pleasant visual experience, certain green infrastructure can provide recreational benefits as well. Philadelphia estimated the number of persons who would use (i.e. walk or bike on) a vegetated acre, as part of their triple bottom line analysis of the Combined Sewer Overflow Long Term Control Plan Update (PWD, 2009). The residents of Alachua County in Florida noted that recreational benefits that stem from green infrastructure were a top priority for the impacts of development. Their concerns for these issues have driven the county's pursuit of GI programs (EPA, 2013). For the Blackberry Creek Watershed Alternative Study, open spaces and natural greenways to preserve and connect significant natural features for valued for aesthetic, recreational, and/or alternative transportation uses (EPA, 2013). Valuation of recreational features stems from economic research on the time and money spent to reach a recreational area.

Noise Reduction: Some green infrastructure systems, such as wetlands or trees, are effective in reducing ambient noise because they can absorb it. CNT (2010) discusses the noise-reducing properties of GI for porous concrete and green roofs, but does not provide a methodology for quantifying these benefits. A case study in Lancaster County, PA notes that positive effects of green infrastructure can arise from noise pollution reduction (EPA, 2014).

Crime Reduction: Researchers from the University of Illinois asked the question "Does Vegetation Reduce Crime?" and came to the conclusion that the greener a buildings surroundings were, the fewer crimes reported (Kuo and Sullivan, 2001). This study examined crime activity levels around apartment buildings in Chicago, and measured differences in the amount of trees and grass cover between sites. Vegetation may deter crime both by increasing informal surveillance and by mitigating some of the psychological precursors to violence. While these are just theories and have not been comprehensively examined, what this research shows is that vegetation does not necessarily facilitate crime by providing cover – a long-held belief among some planners. Instead, a green environment encourages outdoor use, and as such, provides a deterrent because more people are in places where crimes can be committed. The benefits of crime reduction would be derived through data per crime on the avoided costs for the judicial system.

Public Education/Environmental Stewardship. Promoting strategies that seek to change people's behaviors and make them more aware of their environmental impacts helps to cultivate a stewardship perspective in the community about its local natural resources. CNT (2010) notes that community tree planting provides a valuable educational opportunity for residents since in this process they become more aware of the benefits of green infrastructure. Research on urban tree planting has shown that such environmental initiatives make environmentally sound behaviors more likely to occur in the future. Other strategies involving public education and advertising has appeared to be less effective in changing attitudes (Kuo and Sullivan, 2001; and Summitt and Sommer, 1997). The economic valuation of such changes though has not been sufficiently studied for it to be included in a BCA. In this case, only a qualitative assessment of changes in stewardship could be included in a decision framework.

Business Development: Green infrastructure, especially on the scale of a comprehensive green street design can lead to an enhanced sense of place, and increase in foot and bicycle traffic can support retail development. The NRDC found that consumers are willing to spend more on products, visit more frequently, or travel farther to shop in areas with attractive landscaping, good tree cover, or green streets (NRDC, 2013). Case studies by the New York City DOT examined before and after changes in Retail Sales Tax Filings, Commercial Leases & Rents, and City−Assessed Market Value. While the study's methodology does not ultimately prove causality between the street improvement projects and any resulting economic changes, some locations of green street development saw a significant increase in retail sales compared to the changes in retail sales for the borough as a whole.

Job Creation and Economic Impacts: Spending on capital investments and operations and maintenance (O&M) leads to job creation. Moreover, since installation and maintenance of most of these systems requires unskilled labor, the economic benefits of job creation often goes directly to those who may be in most need of work. The total economic impact of capital and O&M expenditures is measured in terms of the number of jobs created, change in income, gross regional product, and sales and property tax revenue. In addition, wider impacts across the region can also be estimated by applying appropriate economic *multipliers*. As an example, PWD (2009) focused on the fact that many of these jobs are for unskilled labor, which provides a valuable social benefit in an urban setting.

2.3 What Evidence Of Benefits Have Been Found Elsewhere?

Economic benefits of storm water management depend on site conditions and characteristics of the green infrastructure systems and program. While CNT (2010) establishes a number of methods for computing benefits, for each set of calculations it is necessary to collect (or establish assumptions) site specific data about BMPs performance and establish analytical standards for the suitability of economic valuation parameters. Despite these constraints and uncertainties, some agencies have pushed forward in collecting data and using these methods. The most recent review of economic evaluations of green infrastructure is found in EPA (2013). This document has developed a fairly comprehensive assessment of the efforts by some utilities to evaluate economic benefits of storm water management. Table 3 presents an excerpt from the EPA (2013) report and indicates that some of case studies performed BCAs, as opposed to other analytical approaches such as cost-effectiveness.

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Table 3: Excerpt of EPA Case Studies on Economic Evaluation of Storm water Management BMPs

Entity	LID/GI program description	Type of analysis	Outcome of analysis
Lenexa Public Works Department, KS	Adoption of LID/GI-oriented development standards, BMPs, and systems development fees as part of the Rain to Recreation program.	Capital cost assessment	Savings of tens to hundreds of thousands of dollars in site work and infrastructure costs with GI BMPs.
Charlotte-Mecklenburg Storm Water Services, NC	Restoration of streams damaged by runoff from development, and BMPs to reduce impacts of rapid development, were assessed to determine impacts on drinking water quality.	Cost-effectiveness	Analysis showed that stream restoration is the most cost-effective way to immediately control sediment in this area.
Capitol Region Watershed District (CRWD), MN	Eighteen BMPs in a 298-acre watershed designed to reduce localized flooding and storm water runoff, improve water quality, enhance recreation in local park.	•Capital cost assessment •Cost-effectiveness	Initial capital cost assessment found substantial cost savings with GI compared with grey infrastructure.
New York City Mayor's Office of Long-term Planning and Sustainability, NY	Distributed GI controls to reduce storm water runoff and CSOs, improve water quality, and increase public access to tributaries, compared to conventional CSO controls such as tunnels and basin storage.	Cost-effectiveness	Cost savings with GI compared to grey infrastructure
Seattle Public Utilities (SPU), WA	Natural drainage system (NDS) projects on residential streets; LID/GI-based storm water regulations and Residential Rainwise Program to encourage customers to reduce the volume of storm water sent to the public system.	Cost-effectiveness	By integrating LID/GI into asset management process, SPU can minimize life-cycle costs to meet established levels of service and balance the risks to minimize life-cycle costs.
West Union, IA	Pilot community for Iowa Sustainable Green Streets Initiative to replace aging infrastructure and reduce localized flooding in downtown area.	•Life-cycle cost analysis •Benefit valuation (avoided costs)	Lower maintenance and repair costs for deicing permeable pavement result in projected savings over the life-span of the pavement.
Kirkland Public Works Department, WA	Integration of LID/GI into conceptual design phase of all capital improvement projects within public rights-of-way.	Quantitative ranking of costs, benefits	LID/GI options for CIP projects are investigated as early in the planning phase as possible.
Kane County, IL	Adoption of county storm water ordinance and corresponding LID/GI-based BMPs, including development approaches that preserve natural areas and use naturalized drainage/retention/detention (i.e., conservation-based development).	Fiscal impact analysis	Study found that conservation development alternative incurs a lower public cost than the conventional alternative.

Table 3: Excerpt of EPA Case Studies on Economic Evaluation of Storm water Management BMPs (Continued)

Entity	LID/GI program description	Type of analysis	Outcome of analysis
Milwaukee Metropolitan Sewerage District (MMSD), WI	Integration of distributed LID/GI strategies into overall planning efforts including facilities plans and CSO control plan; projects on both public and private lands.	•Cost effectiveness •Benefit valuation	Results will be used to help select which projects to implement in the future, and to show where the use of GI is a valid and effective approach
Alachua County Environmental Protection and Public Works Departments, FL	County acquires and preserves open-space lands through ACF program to reduce development impacts and improve water quality.	Benefit-cost analysis (BCA)	Proximity to open space adds to parcel value, for an increase in property tax revenue of several million dollars per year.
Portland Bureau of Environmental Services (BES), OR	Ecoroof Program includes incentives for green roofs on privately owned buildings and green roof requirements for new city-owned buildings.	BCA analysis	Ecoroofs generate significant public and environmental benefits, as well as benefits to developers and building owners (due to extended life of ecoroofs compared to traditional roofs).
Sun Valley Watershed, LACDPW, CA	Goal of watershed-based project was to alleviate localized flooding while providing multiple benefits. Fifteen project elements with LID/GI components.	BCA analysis	Demonstrated potential for multi-objective storm water strategies to provide greater community value than a single-objective flood control strategy would provide.
PWD, PA	Green City Clean Waters Program aims to reduce CSOs and improve water quality in part through distributed GI controls and comprehensive stream restoration program.	BCA analysis	LID/GI-based approaches provide important environmental and social benefits that are generally not provided by grey infrastructure.

A summary of several case studies is presented below. These studies integrated local data with some aspects of the CNT (2010) framework to estimate quantifiable benefits.

Economic Benefits of Green Infrastructure in Milwaukee, WI and Ann Arbor, MI: ECONorthwest (2011), evaluated benefit analyses of storm water management efforts in Milwaukee, WI and Ann Arbor, MI. In *Milwaukee,* the Department of Public Works - Infrastructure Division, manages infrastructure consisting of about 300 miles of sewer pipes, 3,000 miles of municipal pipes, and 3,000 miles of private laterals. A primary focus is to reduce the quantity of total suspended solids entering its waterways by 40 percent by 2013, as required by the Wisconsin Department of Natural Resources (City of Milwaukee, 2011). The Systems Planning Unit in Ann Arbor has a much smaller management responsibility and consists of just 359 miles of underground pipes and over 11,000 inlets and catch basins to manage storm water (City of Ann Arbor, 2011). In both communities, monetizable, quantifiable and qualitative benefits are evaluated (see Table 4) using the methodology established by CNT (2010). Where appropriate and possible, local data was integrated into calculations to estimate benefits. A number of additional assumptions are made to illustrate the scale of benefits that could arise from a much larger future program.

Table 4: Benefits Evaluated in Great Lakes Study

Quantified and Monetized	Quantified, but not Monetized	Qualitative
Avoided costs of reduced storm water runoff and water quality	Flood Reduction	Public Education
Avoided costs related to water quality benefits	Heat Island Effect	
Avoided costs of additional future gray infrastructure capacity	Aesthetics	
Avoided costs of treatment operations and maintenance for combined sewer flows	Improved health and well-being from recreation	
Energy Cost Savings Benefits	Improving well-being by reducing noise pollution	
Decreased air pollution emissions from reduced energy use		
Improved air quality from vegetation on green roofs and trees		
Reduced CO2 equivalent emissions from reduced energy use		
Increased carbon sequestration from trees and green roofs		
Wetland habitat protection		

Economic Benefits of Green Infrastructure in Lancaster, PA: With a population of 60,000, the city has a combined sewer system (CSS) and needed to address burden on the treatment facility when intense precipitation events occurred. The EPA notes that combined sewer overflows (CSOs) discharge approximately 750 million gallons of untreated wastewater and storm water into the Conestoga River (EPA, 2014). To address this issue, Lancaster County published a Green Infrastructure plan which estimated water quality benefits, but not the additional environmental, social, and economic benefits. The EPA published this case study to highlight and bring awareness to quantify and highlight these benefits. The specific benefits they monetized were energy, air quality, and climate-related benefits. They also estimated the avoided capital costs of gray infrastructure, and the avoided wastewater pumping and treatment costs. The methodology used in quantifying and monetizing the benefits followed CNT (2010). They also made several high-level assumptions with regard to long-term reduction, the future distribution of green infrastructure projects, and when the monetary benefits would begin accruing.

Philadelphia Combined Sewer Overflow Long Term Control Plan Update: The purpose of the City's report was to demonstrate the full range of societal benefits of the Green City Clean Waters Program. The program aims to reduce CSOs and improve water quality in part through distributed GI controls and comprehensive stream restoration program. The analysis helped PWD to determine that a GI-based approach, coupled with targeted grey infrastructure, is their preferred approach for city to follow. A table of the monetized benefits over 40 years is presented below. It is assumed that these benefits arise from a 50% level of LID coverage throughout the city.

Table 5: City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 Dollars)

Benefit categories	Value
Increased recreational opportunities	$524.50
Improved aesthetics/property value (50%)	$574.70
Reduction in heat stress mortality	$1,057.60
Water quality/aquatic habitat enhancement	$336.40
Wetland services	$1.60
Social costs avoided by green collar jobs	$124.90
Air quality improvements from trees	$131.00
Energy savings/usage	$33.70
Reduced (increased) damage from SO2 and NOx emissions	$46.30
Reduced (increased) damage from CO2 emissions	$21.20
Disruption costs from construction and maintenance	($5.60)
Total	$2,846.40

Alachua County Environmental Protection and Public Works Departments, FL: The county developed a comprehensive low impact development (LID) / green infrastructure (GI) program based on three different components: (1) LID/GI-based land development policies and regulations developed through the county's Comprehensive Plan; (2) Alachua County Forever (ACF), a conservation and land acquisition program; and (3) a unique governance structure designed to increase interdepartmental collaboration to promote the adoption of LID/GI program elements. To demonstrate the benefits of ACF and alleviate public concerns that the program reduces property tax revenue, the county calculated the benefits for the increase in property values from increased open space. This measure was used to compare with any lost tax revenue to acquire, protect, and manage environmentally significant lands in order to protect water resources, wildlife habitat, and natural areas suitable for resource-based recreation. Twelve thousand seven hundred parcels in the county are close enough to open space to show an increase in value due to their proximity to water. The total impact on their value is just under $150 million, which would result in additional property tax revenues of approximately $3.5 million per year.

Portland Bureau of Environmental Services, OR. The Portland BES performed an analysis of ecoroofs versus conventional roofs to gain support and increase implementation of ecoroofs in the city. Portland receives an average of 37 inches of precipitation per year, which creates an annual volume of storm water runoff of about 10 billion gallons. As part of its storm water management programs, BES has implemented the Sustainable Storm water Management Program, which focuses on green infrastructure initiatives, including the Ecoroof Program.

Table 6: Value of Benefits from 40,000 SQFT Ecoroof (2008 Dollars)

Benefit categories	Total Over 40 Years
Cooling demand reduction	$19,983
Heating demand reduction	$23,509
Carbon reduction	$845
Improved air quality	$104,576
Habitat creation	$25,300
Total	$174,213

Sun Valley Watershed, Los Angeles, California: The Sun Valley watershed is in the San Fernando Valley, about 14 miles northwest of downtown Los Angeles. It encompasses the communities of Sun Valley and North Hollywood. The watershed is approximately 4.4 square miles and six miles in length from north to south.

The economic analysis was undertaken because the county and other stakeholders needed to show that although the costs of the LID/GI-oriented solutions would be much greater than the cost of traditional infrastructure, and they would yield significantly higher benefits. The results of the analysis were used to help to gain public support, bring in outside partners, and raise funds. The tables below show the descriptions of each alternative the value of alternatives compared to a grey infrastructure scenario.

Table 7: Description of Alternatives for Sun Valley Watershed

	1 - Infiltration	2 - Water Conservation	3 - Storm water Reuse	4 - Urban Storm Protection
Description	Widely Distributed Small Projects	Maximizes Wildlife Habitat	Maximizes Storm water Reuse for Industry	Full Conveyance with Regional BMPs
Retention Basin Size	50-Year	50-Year: Subareas 1-6 10-Year: Subareas 7-8	50-Year	10-Year

Table 8: Values by benefit over 50 years (2002 Dollars)

Benefit	Grey Infrastructure	1	2	3	4
County Flood Control					
Regional damage avoidance	$64.46	$64.46	$64.46	$64.46	$64.46
Change in downstream flooding	-$1.03	$5.37	$3.65	$5.37	$3.22
City Flood Control	$10.01	$10.01	$10.01	$10.01	$10.01
Avoided cost of imported water	$0.00	$22.35	$17.89	$24.07	$22.65
Energy Reduction	$0.00	$4.30	$1.70	$4.30	$1.70
Air Quality	$0.00	$20.50	$8.10	$20.50	$8.10
Greenwaste	$0.00	$20.00	$10.00	$20.00	$10.00
Ecosystem Restoration	$0.00	$1.86	$4.04	$4.58	$4.48
Recreation	$0.00	$23.34	$23.34	$23.34	$23.34
Property Values	$0.00	$10.20	$3.90	$10.20	$3.90
Total Benefits	**$73.44**	**$270.47**	**$295.39**	**$274.93**	**$239.95**

3 Summary of Water Quality Improvement Strategies

3.1 Program Background

The Division has been working for several years with other jurisdictions and community groups to establish Water Quality Improvement Plans (WQIPs) for each of its watersheds. WQIPs draw from the processes in developing Watershed Asset Management Plans (WAMPs) and Comprehensive Load Reduction Plans (CLRPs) which aim to protect, preserve, enhance, and restore water quality in receiving waters. WAMPs provide an understanding of critical assets owned by the Division and the management and investment strategies necessary to deliver required services. CLRPs are efforts to identify BMPs and funding levels needed to comply with TMDL and other storm water regulations established by the Regional Water Quality Control Board. These efforts, as described below, have identified a series of projects and initiatives that have been defined as either structural or nonstructural initiatives.

3.2 Structural WQIP Strategies

3.2.1 Types of Strategies

Structural BMPs are physical infrastructures that are designed for site-specific conditions and placed strategically across a watershed to improve water quality. The effectiveness and feasibility of implementing any of these BMPs varies depending on the design and site conditions. For example, the effectiveness of a BMP in enhanced infiltration capacity of a watershed depends on amenable soil types. Other site-specific considerations include the physical land area available for effective implementation and maintenance. Also, the capital and maintenance costs of a BMP influence its feasibility for the Division, especially in comparison to other BMPs which can be implemented more cost-effectively.

Various types of structural strategies have been identified as potentially suitable for San Diego watersheds and have been classified as one of three types: (1) green infrastructure, (2) multiuse treatment areas, and (3) water quality improvement BMPs.[16] Each of these types of structural BMPs is discussed below.

Green Infrastructure

Green infrastructure covers a range of BMPs that are designed to be integrated in a broader site plan to maintain healthy waters, provide multiple environmental benefits, and support sustainable communities. Green infrastructure is distinguished from other methods by making deliberate and effective use of vegetation and soil to manage storm water (USEPA, 2014). Table 9 presents a series of green infrastructure BMPs that can be integrated into site designs and implemented at the site scale (on-site treatment) or street right-of-way scale (green streets).

[16] San Dieguito Potential Strategies Final Draft 4/11/14

Table 9: List of Structural BMPs – Green Infrastructure

BMP*	BMP Description
Bioretention	Shallow vegetated features constructed in green spaces alongside roads, sidewalks, and other paved surfaces. Bioretention includes an engineered soil media designed to encourage pollutant treatment and water storage.
Infiltration Trenches	Narrow, linear BMPs that have similar functions as bioretention areas with variable surface materials, including rock or decorative stone, designed to allow storm water to infiltrate into subsurface soils.
Bioswales	Shallow, open channels designed to reduce runoff volume through infiltration and pollutant removal by filtering water through vegetation within the channel and infiltration into bioretention soil media. Bioswales can serve as storm water conveyance, but the primary objective is water quality enhancement (often referred to as linear bioretention).
Planter Box	Fully contained system containing soil media and vegetation that functions similarly to a small biofiltration BMP, but includes an impermeable liner and underdrain.
Constructed Wetland	Engineered, shallow marsh systems designed to control and treat storm water runoff. Particle-bound pollutants are removed through settling and other pollutants are removed through biogeochemical activity.
Permeable Pavement	Allows streets, parking lots, sidewalks, and other impervious covers to retain their natural infiltration capacity while maintaining the structural and functional features of the materials they replace. Roads such as highways can include PFC overlays which provide water quality benefits when traditional permeable pavement is not suitable.
Sand Filters	Treatment systems that removes particulates and solids from storm water runoff by facilitating physical filtration.
Vegetated Swales	Shallow, open channels that are designed primarily for storm water conveyance. Pollutants such as trash and debris are removed by physically straining/filtering water through vegetation in the channel.
Vegetated Filter Strips	Bands of dense, permanent vegetation with a uniform slope, designed to provide pretreatment of runoff generated from impervious areas before flowing into another BMP as part of a treatment train.
Green Roofs	Roofing systems that layer a soil/vegetative cover over a waterproofing membrane and can reduce runoff through interception and evapotranspiration.

*Source: San Dieguito River WMA Water Quality Improvement Plan (2014)

Table 10 outlines the expected levels of effectiveness in green infrastructure in handling different types of impacts of storm water, including water chemistry and physical and biological impacts. This chart is adapted from the San Dieguito River WMA Water Quality Improvement Plan (2014) provides an initial indication of the kinds of benefits (beyond water quality improvements) that can be achieved by green infrastructure BMPs. In particular, while trash removal is a water chemistry benefit, its removal from streets can lead to more aesthetically pleasing neighborhoods, which in turn can foster economic value. In addition, depending on the extent to which these BMPs improve physical and biological factors, there can be follow-on improvements in recreational value and ecosystem value of streams and riparian areas. It is noted here that only constructed wetlands have the potential to generate tangible improvements in habitat or wildlife.

Table 10: Green Infrastructure BMPs and Pollutant Reduction BMP

	Water Chemistry Benefit									Physical and Biological Benefits			
	Bacteria[1]	Metals	Organics	Sediment	Pesticides	Nutrients	Oil and grease	Dissolved minerals	Trash	Flow rate	Volume reduction	Habitat or Wildlife	Aquatic Life
Bioretention	●	●	●	●	●	◗	●	◗	●	●	●	○	◗
Infiltration Trenches	●	●	●	●	●	●	●	●	●	●	●	○	●
Bioswales	●	●	●	●	●	◗	●	◗	●	●	●	○	◗
Planter Boxes	●	●	●	●	●	◗	●	◗	●	◗	◗	○	◗
Permeable Pavement	◗	●	◗	●	●	◗	◗	◗	◗	●	●	○	◗
Constructed Wetlands	●	●	◗	●	●	●	◗	◗	●	●	◗	●	◗
Sand Filters	●	●	●	●	●	◗	●	○	●	◗	◗	○	◗
Vegetated Swales	◗	◗	◗	●	◗	◗	◗	○	●	◗	◗	○	◗
Vegetated Filter Strips	◗	◗	◗	●	◗	◗	◗	○	●	◗	◗	○	◗
Green Roofs	◗	◗	○	●	○	○	○	○	○	●	◗	○	◗

Key: ● - Primary pollutant reduction; ◗ - Secondary pollutant reduction; ○ - Minimal or no pollutant reduction.

Multiuse Treatment Areas

San Dieguito River WMA WQIP (2014) identifies large-scale treatment areas such as multiuse basins and stream, channel, and habitat rehabilitation projects. These systems are designed as regional facilities that can receive flows from neighborhoods or larger areas and become cost-effective solutions that provide multiple benefits. For example, such systems can be integrated in public spaces such as active (soccer fields) and passive (parks) recreation areas and provide benefits in flood control, ground water recharge, restoration, habitat enhancement, and recreation. In addition streambank projects that reduce erosion can improve water quality and simultaneously improve habitat. Table 11 defines the list of measures considered in San Dieguito River WMA WQIP (2014).

Table 11: List of Structural BMPs – Multiuse Treatment Areas

BMP*	BMP Description
Infiltration and Detention Basins	Large multiuse surface BMPs (on public parcels) that provide treatment through the runoff detention and infiltration (e.g. infiltration basins and dry extended detention basins). These BMPs are designed to hold runoff for an extended period of time to allow water to evaporate into the atmosphere, infiltrate into native soils, or be transpired by vegetation, while accommodating for overflow and bypass during large storm events.
Stream, Channel, and Habitat Rehabilitation Projects	Stream, channel, and habitat restoration or enhancement projects can help sustain habitat for wildlife and provide water quality benefits downstream of these activities.
Other Opportunities	Construction of multiuse treatment areas BMPs on private land to achieve the load reductions. These BMPs are the cost effective and considered a low priority.

Water Quality Improvement BMPs

Additional structural BMPs include systems that supplement the design performance of existing infrastructure. For example, systems that segregate trash includes inlet devices, such as trash guards or racks that capture debris before they enter surface waters. Another example are proprietary commercial products that often aim to use settling, filtration, absorptive/adsorptive materials, vortex separation, and sometimes vegetative components to remove pollutants from runoff. Finally, dry weather flow separation and treatment projects target non-storm water dry season flows and divert these flows for treatment either on-site or to sanitary sewer systems and ultimately waste water treatment plants.

3.2.2 Measuring Impacts of Structural Strategies

The benefits of structural systems - both the type of benefit and the magnitude – depend on the system's design and surrounding site characteristics. Some strategies such as constructed wetlands can generate a range of benefits (which are partially indicated by Table 10) and may also include recreational and aesthetic values. Most of these benefits accrue to the general public who may have access or benefit from proximity to the wetland. Green roofs, on the other hand, create both public benefits in water retention as well as potential private benefits for property owners in terms of energy savings, from additional roof insulation.

The effectiveness of each structural system in generating benefits is determined directly from key physical features associated with its design. That is, each system benefit, whether it includes flood risk reduction, air quality improvement, or aesthetics, depends on a characteristic of the system that is measured in physical units. For example, flood risk reduction benefits depend fundamentally on the quantity of water retained by the BMP – that benefit's *unit of measure*.

The unit of measure of green streets (Figure 1) would certainly include the designs of various BMPs on the street such as bio-swales, permeable pavement and tree plantings.

In aggregate however, a standard green street design would be measured by its length in miles. In addition, the features and length of the green street may also influence the value of properties on either side of it. Site specific characteristics associated with the type of neighborhood (e.g. mixed use, residential, commercial, etc.), population / employment density, socio-economic characteristics (e.g. income, household size), safety conditions and other factors could influence different types of benefits.

Figure 1: Illustration of Sample Structural BMP: Green Streets

Bioswales: can reduce runoff and downstream flood potential and create aesthetically appealing environment

Permeable Pavement: can reduce runoff and downstream flood potential

Tree Plantings: can reduce runoff and downstream flood potential, entrain harmful particulates, create aesthetically appealing environments, lower ambient temperatures

3.3 Nonstructural Strategies

3.3.1 Types of Strategies

The Division and its stakeholders have also identified nonstructural strategies that may achieve water quality improvements. Nonstructural strategies include "those actions and activities intended to reduce storm water pollution, which do not involve construction of a physical component or structure to filter and treat storm water." These strategies include administrative policies, creation and enforcement of municipal ordinances, education and outreach programs, rebate and other incentive programs, and cooperation and collaboration with other watershed or regional partners. In general, many of these initiatives have been implemented by the Division for many years and are considered to be integral to regulatory compliance on a watershed-specific basis.

WQIP documents have organized Nonstructural Strategies into a number of categories (see Table 12). These categories include: Development Planning, Construction Management, Existing Development, Illicit Discharge, Detection, and Elimination (IDDE) Program, Public Education and Participation, Enforcement Response Plan, and Non-JRMP Strategies. Across the watersheds and jurisdictions, a long list of potential nonstructural strategies in each category has been developed – reflecting the differing site characteristics in different locations. A comprehensive list of specific strategies across all of the watersheds is included in Appendix 2.

Table 12: Nonstructural Strategies

Strategy Category	Strategy Description
Development Planning	Program uses Responsible Agencies' land use and planning authority to require implementation of best management practices (BMPs) to address effects from new development and redevelopment.
Construction Management	Program addresses pollutant generation from construction activities associated with new development or redevelopment.
Existing Development	Program addresses pollutant generation from existing development including commercial, industrial, municipal, and residential land uses. It includes stream, channel, and habitat restoration and retrofitting in areas of existing development.
Illicit Discharge, Detection, and Elimination (IDDE) Program	Program actively detects and eliminates illicit discharges and improper disposal of wastes into the MS4.
Public Education and Participation	Promotes and encourages the development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water to the maximum extent practicable (MEP), prevent controllable non-storm water discharges from entering the MS4, and protect water quality standards in receiving waters.
Enforcement Response Plan	Enforcement of each JRMP is required.
Non-JRMP Strategies	Strategies that are outside of the JRMPs, but are designed to effectively prohibit non-storm water discharges to the MS4, protect the beneficial uses of receiving waters from MS4 discharges, or achieve the interim and final numeric goals identified in the Water Quality Improvement Plan.

3.3.2 Measuring Impacts of Nonstructural Strategies

The economics perspective on nonstructural strategies is manifested in the change that they create, which in turn causes a change in value for the community. In particular, the impact of some nonstructural strategies that are directly related to structural systems, such as new design standards for BMPs, generates value when the design standard is used to improve BMP performance. The value of this nonstructural strategy is captured through the value of the structural systems that are implemented. Other nonstructural strategies directly generate value that is separate from a structural BMP. For example, an educational campaign that aims to reduce litter would directly target people's behavior and its effectiveness would be determined by how many people's behavior is changed. The value of this change would be captured by benefit categories associated with improved community livability and business development.

To reflect these differences in nonstructural strategies, we have developed several categories to differentiate them in terms of how they generate value. These categories include strategies that: (a) Increase # of structural systems; (b) Improve structural systems performance; (c) Initiatives to change behavior; and (d) Initiatives to reduce pollutants directly. The revised grouping of specific nonstructural strategies is briefly described in Table 13.

Table 13: Nonstructural Categories by Type of Impact and Identified Strategies

Changing Behavior to reduce pollutants at the source
Implement pet waste program
Identify and reduce incidents of power washing discharges from nonresidential sites.
Require BMPs to address pesticides, herbicides, and fertilizers issues
Implement Illicit Discharge, Detection, and Elimination (IDDE) Program
Implement a public education and participation program
Enhance education and outreach
Technical education and outreach on the MS4 Permit and WQIP
Implement escalating enforcement responses to compel compliance
Continue participating in source reduction initiatives.
Improve / Maintain BMPs or LIDs
Update BMP Design Manual procedures
Administer an alternative compliance program
Oversee implementation of BMPs during the construction
Require implementation of minimum BMPs for existing development
Gather monitoring information about priority conditions or beneficial uses
Collaborate with entities potentially including, but not limited to:
Increasing # of BMPs or LIDs
For all development projects, ensure source control BMPs
Amend municipal code to encourage LID
Train staff on LID regulatory changes and LID Design Manual.
For PDPs, require implementation of on-site structural BMPs or LIDs
Promote and encourage implementing designated BMPs at residential areas.
Develop pilot project to identify and carry out site disconnections in targeted areas.
Promote and encourage implementation of designated BMPs in nonresidential areas.
Monitor for erosion, and slope stabilization on municipal property.
Identify sites for pilot study to test Permeable Friction Course (PFC)
Identify candidate areas for retrofitting projects
Identify areas for stream, channel, or habitat rehabilitation projects
Enforcement of actionable erosion and slope stabilization issues
Conduct a feasibility study on urban tree canopy (UTC) program
Removing pollutants or sources directly
Implement operation and maintenance activities
Implement controls to prevent infiltration of sewage into the MS4
Implement operation and maintenance activities for public streets

Require sweeping and maintenance of private roads and parking lots in targeted areas.
Develop a program to address and capture trash and debris.
Sanitation and trash management for persons experiencing homelessness.
Protect areas that are functioning naturally.

As mentioned above, the first two of these nonstructural categories relates directly to structural systems themselves. In this case, whether the change in BMP adoption is due to training in the community or general promotion of BMP adoption, the success of these strategies would be determined directly by how many additional BMPs are installed and then by the various benefits generated by their installation. Similarly, new design standards and performance monitoring would be measured by the improvement in the performance of installed structural systems.

On the other hand, nonstructural strategies can generate water quality and other benefits on their own. For example, some of these strategies entail education, enforcement and outreach activities which attempt to alter behavior that leads to water quality pollution. These strategies may at the same time lead to an overall aesthetically better environment with less litter on the street. In addition, programs to promote rain barrels and other water harvesting systems on private property can generate benefits to the property owner and the general public. Measured in terms of their water holding capacity, these systems have the potential to offset water demand for irrigation purposes which has the dual effect of reducing water costs for the owner and water treatment demand from the utility. Lower water demand would reduce energy demanded and associated pollutants.

Figure 2: Illustration of Nonstructural BMP: Water Harvesting

Irrigation costs savings:
Quantity of water retained for irrigation purposes
(retained water also reduces energy emissions from lower energy use at the water treatment plant)

Each of these types of strategies will be discussed in greater detail relative to the benefits that they can generate in the next chapter.

4 Accounting for Benefits of BMP Strategies in San Diego

Discussions above on the economic benefits of storm water management and the varied types of structural and nonstructural BMPs strategies under consideration by that the Division sets up the potential to evaluate strategies with an economic framework. The challenge in performing an economic analysis is that some benefits may not be quantifiable, let alone monetizable. In that case, the Division faces some options in how to account for benefits that are perceived to be relevant in decision making. This section begins with an outline of the types of benefits which could be applicable to different categories of strategies and then closes with a discussion on the options for analytically accounting for benefits with different levels of information.

4.1 Evaluation of Benefits for BMP Strategies

This assessment of the applicability of benefits to different BMP strategies represents an initial effort to characterize and differentiate BMPs by the value that they may create for the economy, environment and community. In a series of tables (Table 14) through Table 17), each category of benefit is evaluated relative to applicability for each type of structural and nonstructural strategy. This initial assessment determines for each strategy type whether a benefit can be: (a) monetized; (b) monetized but depending on site specific conditions; (c) quantified but not monetized; or (d) qualitatively evaluated.

To facilitate the review of these tables, a standard symbol key is created to establish how benefits may be evaluated for each strategy.

Key to Symbols for Table 14 through Table 17	
●	Monetizable
☉	Monetizable, but site-specific
⊗	Quantifiable
○	Qualitative

The following delineation of how benefits can be evaluated for a general strategy can only be viewed as our initial assessment. Recall that Table 13 briefly identifies individual strategies under each of these major groups. At this stage, only a general indication of applicability of benefits is discussed. Further evaluation of benefits per strategy would be developed in a subsequent report.

4.1.1 Structural Strategies – Economic and Environmental Benefits

Table 14 represents the additional economic and environmental benefits that could arise from various structural strategies. As shown, many benefits are readily monetizable for *Green Infrastructure* strategies. This finding reflects the fact that much of the existing research that can be applied in San Diego has focused on the various BMPs identified as green infrastructure. Such research and the various storm water management BCA case studies that have been produced provide standardized methods, data, and evidence that can be applied to new sites and projects. As noted in the table, with some additional data on site conditions (e.g. evidence of flood risk, and irrigation demand, for example), many of the green infrastructure systems have the potential to be monetized. Only benefits related to habitat creation would be unlikely to be monetized. The reason is that not only to these types of benefit calculations require detailed biological surveys, but predictions on the improvement in habitat services with green infrastructure are not well understood at present. Any assessment of monetary benefits would be highly uncertainty and thus, this type of benefit is better characterized in quantitative terms, such as in units of habitat area created.

Multiuse Treatment Area strategies differ from green infrastructure because of the scale and placement of these systems. Benefits can arise from these strategies, especially in flood control because of the volumes that can be potentially detained but the quantification of benefits depends on whether there is a downstream flooding risk. The planted material in these systems can provide benefits in air particulate entrainment, carbon sequestration, and habitat creation but the evidence is not established well enough to characterize these impacts in monetary terms. Other benefits would entail a qualitative assessment.

Water Quality Improvement strategies do not have as clear an impact on economic and environmental benefits as green infrastructure and multi-use treatment areas. For example, trash guards or racks that capture debris before they enter surface waters can improve fish habitat but do not have enough supporting documentation to clearly assess benefits from some of the improved livability characteristics. If less trash in surface waters can be attributed to less trash on neighborhood streets, associated benefits in business development and social capital could arise, but such a connection is not likely to be quantifiable.

Table 14: Structural Strategies – Economic and Environmental Benefits

Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement
Flood Risk Reduction	⊙	⊙	⊙
Irrigation Cost Savings	⊙	○	○
Energy Cost Savings	⊙	○	○
Air Particulate Entrainment	●	⊗	○
Climate Impacts	●	⊗	○
Habitat Related Benefits	⊗	⊗	⊗
Air Quality Emission Reduction	●	○	○
GHG Emission Reduction	●	○	○

4.1.2 Structural Strategies – Community Livability Benefits

Community livability benefits from structural systems (Table 15) represent benefits which directly or indirectly enhance local development and quality of life. These benefits are largely derived from the physical features of structural strategies in creating benefits to local residents and property owners. For example, green roofs are noted in their ability to provide noise insulation in a building and tree plantings along green streets can lead to local retail business development because the environment is a more pleasant place to shop.

Similar to economic and environmental benefits in the table above, the applicability of community livability benefits to *Green Infrastructure* also depends on site specific characteristics. For example, the influence of aesthetic improvements on property values usually depends on the type of neighborhood (e.g. residential, commercial, or mixed-use areas). In commercial districts, monetized benefits would be observed in property values, increased sales or employment levels.

The other types of strategies, *Multiuse Treatment Areas* and *Water Quality Improvements*, have fewer types of benefits which can be quantified, let alone monetized. *Multiuse Treatment Areas* certainly have the potential to be located in areas that by design can create recreational opportunities. However, the type of features at the site depends on how it can be used for recreational purposes. The choice of plant materials (e.g. tree species) at the site would affect aesthetics and heat island / health effects but it depends on the location and installation scale of these systems. For *Water Quality Improvements*, it is not clear if there are quantifiable benefits that extend beyond water quality improvements themselves and thus, these benefit categories may be evaluated only in qualitative terms.

Table 15: Structural Strategies – Community Livability Benefits

Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement
Heat Island Effect	⊙	⊙	○
Aesthetics	⊙	⊙	○
Recreational Benefits	⊙	⊙	○
Noise Reduction	⊗	○	○
Business Development & Jobs	⊙	○	○
Crime Reduction	⊗	○	○
Public Education/ Environmental Stewardship	⊗	⊗	⊗

4.1.3 Nonstructural Strategies – Economic and Environmental Benefits

The potential applicability of economic and environmental benefits for *Nonstructural Strategies* is presented in (Table 16). As discussed above, some types of nonstructural strategies relate directly to structural systems by *Increasing the Number of Structural*

Systems and *Improving the Structural Systems Performance*. Accordingly, estimating monetary benefits in of these is directly linked to whether the influence of a nonstructural strategy on implementing a structural system can be quantified. If so, then benefits are assessed relative to the structural system itself. The assessment of benefit estimation in the first two columns is therefore similar to that of structural systems, assuming though that the effectiveness of these nonstructural strategies can be estimated.

The two other nonstructural approaches, *Initiatives to Change Behavior* and *Initiatives to Reduce Pollutants Directly,* generate benefits from their own effectiveness in changing behavior or pollution control initiatives. Initiatives to Change Behavior primarily target efforts to encourage improved environmental stewardship and storm water protection throughout the community. Various types of actions then that people may take who are more area of environmental impacts include adoption of rain barrels, reducing litter, and reducing unnecessary levels of pesticides, herbicides and fertilizers. These types of activities could generate a range of economic and environmental benefits, some of which can be monetized if there is sufficient site specific information. In addition, *Initiatives to Reduce Pollutants Directly*, including a number of public agency initiatives in street sweeping, storm water system maintenance and trash removal, can also generate quantifiable and monetizable benefits. On the other hand, street sweeping initiatives entail some amount of environmental costs (or “negative benefits”) associated with emissions from vehicle use. These costs could be compared with any benefits created from cleaner streets.

Table 16: Nonstructural Strategies – Economic and Environmental Benefits

Strategy	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives to Change Behavior	Initiatives to Reduce Pollutants Directly
Flood Risk Reduction	⊙	⊙	⊙	○
Irrigation Cost Savings	⊙	⊙	⊙	○
Energy Cost Savings	●	⊗	⊙	●
Air Particulate Entrainment	●	⊗	⊙	⊙
Climate Impacts	●	⊗	⊙	⊙
Habitat Related Benefits	⊗	⊗	⊗	⊗
Air Quality Emission Reduction	●	⊗	⊙	●
GHG Emission Reduction	●	⊗	⊙	●

4.1.4 Nonstructural Strategies – Community Livability Benefits

The effectiveness of nonstructural strategies in enhancing various aspects of community livability are similar to those for economic and environmental outcomes. That is, some of these strategies influence the adoption and performance of structural systems and some aim to change behavior and municipal operations. Also, similar to the structural strategies for the same types of benefits, fewer of these benefits can be evaluated without some site specific information. For the most part though, the evaluation of potential benefits for green infrastructure has been applied to nonstructural systems that aim to increase the numbers and performance of these systems.

Strategies which seek to change behavior such as proper storage of pesticides or the use of rain barrels/water harvesting can have a positive impact, but the scale of that impact will be dependent upon factors such as the number of persons or households who change their behavior. This same uncertainty applies to strategies to reduce pollutants directly. While there is likely to be a net positive impact on society, these impacts on the broader quality of life are less clear. With respect to improved education and awareness, it is possible to quantify the numbers of people who attended a class or have been exposed to an advertising campaign, it is less clear how this information changes behavior or leads to increased number or maintenance of BMPs.

Table 17: Non Structural Strategies – Community Livability Benefits

Strategy	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives to Change Behavior	Initiatives to Reduce Pollutants Directly
Heat Island Effect	⊙	⊙	⊙	O
Aesthetics	⊙	⊙	⊙	⊙
Recreational Benefits	⊙	⊙	⊙	⊙
Noise Reduction	⊗	⊗	⊗	⊗
Business Development & Jobs	⊙	⊙	⊙	⊙
Crime Reduction	⊗	⊗	⊗	O
Public Education/ Environmental Stewardship	⊗	⊗	⊗	⊗

4.2 Review of BMP Prioritization Frameworks

In consideration of the types of benefits that can and cannot be estimated with data for various types of BMP strategies, a number of options are available for summarizing the likely outcomes for decision making. As noted in the tables, some benefit categories are readily monetized under certain conditions and others require site specific information to perform computation. Many other benefits may arise from a specific BMP strategy but cannot be explicitly quantified. Evaluations of any of these benefits for consideration in decision making also entails some significant uncertainties.

Accordingly, several approaches for summarizing benefits and impacts for decision making are available including: cost-effectiveness, benefit-cost analysis, multi-criteria analysis, and SROI. Each of these approaches has strengths and weaknesses for meeting the Division's objectives in developing a prioritization strategy. Overall though, each method can be implemented in a process that applies principles of economics, even in multi-objective decision analyses which do not require monetization, so that the categories of benefits are not overlapping or over-estimating value.

Cost-Effectiveness Analysis (CEA): This type of analysis focuses on identifying the best value for money in achieving a specific goal, such as storm water reduction. The process is not necessarily identifying the least costly strategy but the one that generates the greatest quantity of a goal per unit of cost (e.g. dollars per gallon of water detained). Costs in these analyses include the capital, maintenance and operations for implementing. This type of analysis is suitable for evaluating projects in which outcomes (benefits) can not be measured in dollar units but can be quantified. Cost-effectiveness analyses often apply a 'knee-of-the-curve' criterion to identify selecting the most cost-effective strategy because beyond this level of investment cost the effectiveness may increase but at a declining rate. These analyses have been used by communities across the country to identify opportunities for saving money while achieving storm water management goals.

Benefit-Cost Analysis (BCA): Since storm water BMPs can offer more benefits than conventional storm water management systems, cost-effectiveness analysis fails to offer decision makers adequate information for evaluating the alternatives (MacMullen, 2007). Benefit-cost analyses attempt to monetize as many benefits as possible to compare results with costs. This approach is a more direct way of accounting for multiple environmental, societal and economic benefits on a common basis and is not limited to a single goal as is often performed in a conventional cost-effectiveness framework. In some cases, direct environmental value cannot be computed directly, but observed from avoided damage costs or inferred from changes in property values. BCAs account for separate evaluation of benefit categories provided that they are not overlapping. In addition, BCA can be used to evaluate the benefits and costs to individual stakeholders, and comparison with strictly financial benefits with combined environmental and societal benefits – all in the same units of measure. The comparison of costs and benefits allows an explicit consideration of the trade-offs in project options. A BCA can determine whether the benefits of preservation (or restoration) are "worth" the costs and when the project is best implemented. In this sense, it ensures that the limited resources used to provide goods and services to society are used in the most efficient way—that is, to achieve the greatest net benefit (NRC, undated). The overall economic worth of an option can be summarized with a Net Present Value (NPV) or

Benefit/Cost Ratio (BCR).[17] BCA results do not incorporate perspectives on who gains or loses but whether the overall net benefits justify the investment. [18] Also, where impacts are perceived to be important but a lack of data is available to assign monetary values to it, additional consideration must be given beyond BCA metrics. For example, a trade-off analysis can be used to compare monetary net benefits with non-monetary impacts to determine a best overall value.

Economic Impact Analysis (EIA): The creation of jobs and business development is a direct and tangible measure of value to the community from expenditures to install storm water BMPs. As mentioned above, since these systems can be installed by low-skilled labor, implementation of these types of systems can provide opportunities for some of those who are most in need. Economic impact analyses trace the levels of expenditures on BMPs through the economy to reveal a total impact for the region. Also, green infrastructure tends to use more local labor and materials compared to grey infrastructure and as such would generate a larger local economic impact. The results can be determined in units of numbers of jobs created, increased income, value added, output, and tax revenue. To many stakeholders, these outcomes are more tangible because the results are shown in units that can be related to the unemployment rate and in gross regional product. For decision making purposes, economic impacts are directly proportional to the level of expenditure. As a result, larger projects would appear to provide greater value even if they are not the most cost-effective. These analyses also do not account for benefits that affect the local community and environment.

Multi-Objective Decision Analysis (MODA): For some project impacts, quantitative and monetary metrics are difficult to determine and the appropriateness of any related assumptions would be highly uncertain. MODA formalizes the process of including non-monetary characteristics of a project into decision making. Just like monetary measures, non-monetary measures try to account in a transparent way stakeholders' preferences for certain characteristics. These preferences are the basis for weights on criteria, which are used to compute an index for ranking projects. Non-monetized performance measures may be weighted with monetary values to produce a single performance metric, or reported alongside monetized values for assessing tradeoffs in decisions. These approaches can be as simple as establishing an equal weight and equal score to all benefit categories – whether they can be monetized or not – to sophisticated frameworks in which non-monetary and monetary benefits are scored and weighted in ways that can be consistent

[17] The NPV is the difference between the present value of benefits and the present value of costs. The present value of benefits is the discounted sum of all future benefits. The present value of costs is the discounted sum of all future costs. The BCR is a ratio of the present value of benefits to the present value of costs. It measures how much benefit would be obtained for each unit of cost invested in a project or policy.

[18] In theory, an initiative or project would be rated positively if the benefits to some are large enough to compensate the losses of others, assuming some mechanism existed.

with economic principles. The drawback is that weights are subjective and not based on economic theory or evidence.

Sustainable Return on Investment (SROI): SROI is a proven, economics-based method for appropriately estimating the monetary value of infrastructure. In such cases, the SROI process first identifies measurable performance indicators that can determine the impact of the infrastructure in specific categories of monetizable benefits. In the context of storm water, benefit categories can include those readily monetized as well as those with some quantitative indicators. In this way, SROI uses stakeholder input to estimate values for inclusion in monetary valuation. The SROI process has several notable features that separate it from more conventional evaluation methods. For instance, true to its economics roots, SROI ensures that key performance indicators do not measure overlapping outcomes which would 'double-count' benefits. In addition, the SROI process is marked by its transparency in accounting for uncertainty through Monte Carlo simulation. Uncertainty in the performance, cost and unit values of green infrastructure benefits would be modeled with probability distributions that account for the entire range of reasonable outcomes. Through Monte Carlo simulation, the full range of value for each strategy would be revealed and decisions can be made relative to the upside and downside risk. To be transparent, the probability distributions are established through facilitated discussions in a workshop setting.[19] The discussions are guided towards reaching consensus on how to best use available evidence, including the formation of quantitative descriptions of the uncertainty in the data.

Each of these approaches has strengths and weaknesses for the Division's purposes. For example, BCA is an established approach for evaluating the worthiness of an investment, such as green infrastructure. Benefits which cannot be monetized because they lack sufficient evidence would be treated in a qualitative assessment, but not included in a benefit-cost comparison. In such contexts a MODA approach can be taken to establish weights and scores for non-monetary outcomes and produce an index of value that can be compared with BCA results. Alternatively, an SROI approach can be undertaken that establishes monetary values for all key benefit categories through a collaborative review of evidence and then risk analysis methods are applied to quantify the uncertainty in quantitative and monetary parameters. MODA methods in establishing weights and scores can be used to support SROI results but ultimately with a SROI process, all key categories of benefits would be evaluated in monetary terms.

The next step for the Division is to develop a sound basis for using this information to prioritize BMPs across each watershed. Many challenges arise in prioritizing BMP strategies with the types of varying benefits presented in Chapter 4. Ideally, a prioritizing approach would be objective, based on site-specific and peer-reviewed evidence,

[19] An initial workshop was held in May in San Diego to discuss benefit categories, strategies and decision making frameworks. Comments received from this workshop are included in Appendix 3.

account for life cycle outcomes and reflect various sources of uncertainty. Several prioritization options exist that address some of these goals for the framework.

5 Summary of Key Findings

Our findings in this report indicate that many types of benefits can accrue to local residents, businesses, and the general public. Computing benefits of BMPs has been standardized to some extent in the Center for Neighborhood Technology (CNT) report which outlines the data and calculations for a number of benefits (CNT, 2010). For the Division, a similar calculation process could be implemented and it would be consistent with efforts implemented in other cities. However, a significant level of uncertainty would arise in preparing such estimates without specific data on BMP designs and activities for each strategy as well as site specific information about where they would be implemented.

The next best evaluation strategy for the Division at present would entail a simplified assessment of the likely *existence* of quantifiable benefits for each strategy. In this report, we have evaluated the degree to which benefits can be quantified and potentially monetized for each type of strategy. Drawing from the previous tables in Chapter 4, the results of this assessment are shown in Table 18. A “Yes” in one of the table cells indicates that there would be sufficient evidence to quantifiably determine the value of a strategy, provided that information about the strategy and implementation location is better understood. In this high-level summary, it may be assumed that if a quantifiable benefit exists, they would be large enough to generate observable public value and influence decisions accordingly.

These initial findings however must be developed in more detail to provide practical use in prioritizing strategies for the Division. In particular, the feasibility of estimating benefits must assessed for each individually identified strategy (see Appendix 2), not its strategy group as shown in Table 18. With this information, the Division can establish an initial indication of specific strategies that provide the best value. This effort is planned for phase two of this project.

Table 18: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies

	Structural			Nonstructural			
Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives To Change Behavior	Initiatives To Reduce Pollutants Directly
Flood Risk Reduction	YES	YES	YES	YES	YES	YES	
Irrigation Cost Savings	YES			YES	YES	YES	
Energy Cost Savings	YES			YES		YES	YES
Air Particulate Entrainment	YES			YES		YES	YES
Climate Impacts	YES			YES		YES	YES
Habitat Related Benefits							
Air Quality Emission Reduction	YES			YES		YES	YES
GHG Emission Reduction	YES			YES		YES	YES
Heat Island Effect	YES	YES		YES	YES	YES	
Aesthetics	YES	YES		YES	YES	YES	YES
Recreational Benefits	YES	YES		YES	YES	YES	YES
Noise Reduction							

	Structural			Nonstructural			
Strategy	**Green Infrastructure**	**Multiuse Treatment Areas**	**Water Quality Improvement**	**Increase # Of Structural Systems**	**Improve Structural Systems Performance**	**Initiatives To Change Behavior**	**Initiatives To Reduce Pollutants Directly**
Business Development & Jobs	YES			YES	YES	YES	YES
Crime Reduction							
Public Education/ Environmental Stewardship							

6 Bibliography

American Forests. (2003). Urban Ecosystem Analysis Delaware Valley Region; Calculating the Value of Nature. Accessed February 2010.

American Planning Association. (2011). How Cities Use Parks for Green Infrastructure

Braden, J.B., Johnston, D.M. (November/December, 2004). Downstream Economic Benefits from Storm-Water Management. Journal of Water Resources Planning and Management

Burden, D. (2006). 22 Benefits of Urban Street Trees. s.l.:Glatting Jackson and Walkable Communities, Inc..

Bureau of Environmental Services, City of Portland. (2008). Cost Benefit Evaluation of Ecoroofs.

Canada Mortgage and Housing Corporation. (March, 1999). Greenbacks from Greenroofs: Forging a New Industry in Canada.

Center for Neighborhood Technology (2010). The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits.

City of Ann Arbor. 2011. Storm water Management. Retrieved from: www.a2gov.org/government/publicservices/systems_planning/waterresources/Storm water/Pages/Storm waterMgmt.aspx

City of Milwaukee Department of Public Works, Infrastructure Division. 2011. Storm Water Management.Retrieved on August 15, 2011 from http://city.milwaukee.gov/mpw/divisions/infrastructure/Storm waterManagement.htm.

City of Portland. (2010). Portland's Green Infrastructure: Quantifying the Health, Energy, and Community Livability Benefits. Bureau of Environmental Services

Clark, C., Busiek, B. and Adriaens, P. (2010). Quantifying Thermal Impacts of Green Infrastructure: Review and Gaps, Washington DC

Clark, Corrie, Adriaens, Peter, Talbot, F. Brian. (2006). Green Roof Valuation: A Probabilistic Economic: Analysis of Environmental Benefits

Columbia University Center for Climate Systems Research & NASA/Goddard Institute for Space Studies; Hunter College-CUNY;SAIC. (2006). Mitigating New York City's Heat Island with Urban Forestry, Living Roofs, and Light Surfaces

District of Columbia Water and Sewer Authority. (2002). Combined Sewer System Long Term Control Plan.

ECONorthwest. (December, 2011).Economic Benefits of Green Infrastructure: Great Lakes Region.

Ecosystem Valuation (http://www.ecosystemvaluation.org/big_picture.htm). 2007. Accessed February 2010.

Environmental Protection Agency (March 2014). Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control.

Environmental Protection Agency. (August 2013).Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure Programs.

Environmental Protection Agency. (February 2014). The Economic Benefits of Green Infrastructure, A Case Study of Lancaster, PA.

Escobedo, F., Seitz, J. A. & Zipperer, W.(2012). Carbon Sequestration and Storage by Gainesville's Urban Forest, Gainesville: University of Florida IFAS Extension.

European Commission: Biodiversity Unit. (September 2013). Non Structural Measures and Green Infrastructure Solutions.

Getter, K. L. et al. (2009). Carbon Sequestration Potential and Extensive Green Roofs. Environmental Science & Technology, Issue 43, pp. 7564-7570.

Glaser, Edward; Laibson, David; Sacerdote, Bruce. (2002) An Economic Approach to Social Capital. The Economic Journal

Grimmond, C. et al. (2010). Climate and More Sustainable Cities: Climate Information for Improved Planning and Management of Cities (Producers/Capabilities perspective). Procedia Environmental

Haugland, J. (2007). Gently Down the Stream: Economic Benefits of Conservation Development. Conservation Research Institute.

Kuo, Frances, Sullivan, Frances. (May, 2001) Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Environment and Behavior, Volume 33 No.3

Liu, K. & Bass, B. (2005). Performance of Green Roof Systems. Atlanta

MacMullen, E. (2007). Using Benefit-Cost Analyses to Assess Low-Impact Developments. Presentation Abstract for the 2nd National Low Impact Development Conference.

McPherson, E. G. et al. (2007). Northeast Community Tree Guide: Benefits, Costs, and Strategic Planting, Albany: U.S. Department of Agriculture, Forest Service.

National Research Council of the National Academies. Updated. Valuing Ecosystem Services: Toward Better Environmental Decision-Making. Accessed February 2010.

Natural Resources Defense Council. (2006). Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows.

Natural Resources Defense Council. (December, 2013). The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value

New York City Department of Transportation. (2014). The Economic Benefits of Sustainable Streets.

Northeast Ohio Regional Sewer District. (April, 2012). Green Infrastructure Plan

Nowak, D. J. & Crane, D. E. (2001). Carbon Storage and Sequestration by Urban Trees in the USA. Environmental Pollution, Volume 116, pp. 381-389.

Pepper, Paula. (June, 2012). Quantifying Carbon Storage in Urban Trees. U.S. Department of Agriculture, Pacific Southwest Research Station

Powell, L. M., Rohr, E. S., Canes, M. E., Cornet, J. L., Dzuray, E. J., and McDougle, L. M. (2005). Low-Impact Development Strategies and Tools for Local Governments: Building a Business Case: Report Lid50t1. LMI Government Consulting.

Rosenzweig, C., Gaffin, S. & Parshall, L. (2006). Green Roofs in the New York Metropolitan Region, New York: Columbia University Center for Climate Systems Research.

Ryerson University. (2005). Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto, Ontario: Ryerson University.

Scherba, A., Sailor, D., Rosenstiel, T. & Wamser, C. (2011). Modeling impacts of roof reflectivity, integrated photovoltaic panels and green roof systems on sensible heat flux into the urban environment. Building and Environment, Volume 46, pp. 2542-2551.

Stratus Consulting. (2009). Supplemental Documentation Volume 2,Triple Bottom Line Analysis, Philadelphia Combined Sewer Overflow Long Term Control Plan Update.

The Earth Institute at Columbia University. (2004). Green roofs in the New York metropolitan region, New York

The Trust for Public Land. (2013). The Economic Benefits of Clean Ohio Fund Conservation.

U.S. Department of Agriculture. (September 2010). Calculating the Green in Green: What's an Urban Tree Worth? Science Findings. Issue 126,

U.S. Department of Transportation. (2006). Guidelines for Analysis of Investments in Bicycle Facilities, NCHRP Report 552

U.S. Environmental Protection Agency. (1999). Preliminary Data Summary of Urban Stormwater BMPs

U.S. Environmental Protection Agency. (2008). Reducing Urban Heat Islands: Compendium of Strategies - Green Roofs.

U.S. Environmental Protection Agency. (2008). Reducing Urban Heat Islands: Compendium of Strategies -Trees and Vegetation

U.S. Environmental Protection Agency. (2014). Water: Green Infrastructure. Accessed March 6, 2014. http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm.

U.S. Environmental Protection Agency. (October, 2011). Handbook on the Benefits, Costs, and Impacts of Land Cleanup and Reuse.

University of North Carolina Environmental Finance Center. Accessed March 2010.

Wachter, S. M. and Gillen, K. C. (2006). Public Investment Strategies: How They Matter for Neighborhoods in Philadelphia. The Wharton School - University of Pennsylvania.

Watcher, Suasn and Wong, Grace. (2008) What Is a Tree Worth? Green-City Strategies, Signaling and Housing Prices. Real Estate Economics Vol 36.

Water Environment Research Foundation (WERF). Economic Evaluations of Stormwater BMPs. (2014). Accessed on June, 2014: http://www.werf.org/liveablecommunities/toolbox/economic.htm

Wise, S. (September 2007). Bringing Benefits Together: Capturing the Value(s) of Raindrops Where They Fall. Center for Neighborhood Technology. Presented at the U.S. EPA Wet Weather and CSO Technology Workshop, Florence, KY

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Appendix 1: Benefit Calculations

This appendix discusses the quantitative calculations and data involved in estimating benefits for those categories which can be converted to monetary values, given site specific data. Benefit categories that can be readily quantified and monetized are discussed here. Benefit categories that are not included here are: Habitat Creation Benefits, Heat Island Effects, and Environmental Awareness / Stewardship.

Flood Risk Reduction Benefits

By reducing the volume of storm water runoff, the proposed strategies can reduce the frequency and severity of flooding. The impact of green infrastructure on flooding is highly site and watershed specific, and thus this guide does not provide general instructions for quantifying the reduction in flood risk resulting from a green infrastructure program. There are several methods[20] for valuing the impact of flood control:

- Hedonic pricing to examine how flood risk is priced into real estate markets;
- Insurance premiums paid for flood damage insurance as a proxy for the value of reducing the risk of flood damage;
- Avoided damage cost approach; and
- Contingent valuation methods

The diagram presents a high level overview of how the benefits could be monetized. The 'Increase in Flood Control' could be monetized using any of the methods suggested above. Some methods have more robust information than others. CNT recommends using a range of 2–5 percent property value increase for removal from the floodplain (CNT, 2010).

Figure 3: Flood Control Benefits

[20] Downstream Economic Benefits From Storm-Water Management. Journal of Water Resources Planning and Management. Braden, J.B. and D.M. Johnston. November/December, 2004

Irrigation Cost Savings

The method for determining the irrigation cost savings begins with quantifying the reduction in water demand from utilities based on the amount that is harvested on site.

This amount can be calculated by using the various water retention factors for the various green infrastructure and multiplying by the annual precipitation.

A diagram is provided here that determines benefits of retention based on cost avoidance. This information would be used in calculating the Decrease in Potable Water. The cost of the water would be derived from local utilities.

Figure 4: Irrigation Cost Savings

Table 19: Green Infrastructure Retention Parameters

	Amount Retained	Unit	Scale
Water Harvesting	0.62	Gallons of runoff	Per inch of Rain

Source: CNT, 2010, McPherson, E. et al. 2006

Energy Cost Savings

The most important step in this calculation will be the reduced energy needs which will depend on the number of buildings which will benefit from the temperature control provided by green infrastructure and LID and the scale of LID/GI implementation. The data on the physical characteristics of GI to insulate or reduce energy use are provided as well.

Figure 5: Energy Cost Savings

The first step to valuing the benefits of reduced energy use is determining the amount of energy saved by BMP. The benefit of energy savings can be terms of kilowatt hours (kWh) of electricity and British thermal units (Btu) of natural gas reduced.

As noted, the total reduction is very specific to the type of improvement/change. The actual benefits realized in terms of energy savings due to the implementation of a green roof will be significantly impacted by the following variables:

- Growing media composition, depth and moisture content
- Plant coverage and type
- Building characteristics, energy loads and use schedules
- Local climate variables and rainfall distribution patterns

These characteristics will influence the R values for conventional and green roofs in region (which will be used to calculate the annual energy savings from reduced energy needs). Other data needs are:

- Annual number of cooling degree days (°F days) in your region
- Annual number of heating degree days (°F days) in your region

Having calculated the direct kWh and BTU saved in reduced building energy use, it is possible to assign a dollar value to these savings.

One may calculate the direct cost savings by multiplying the kilowatt hours or BTUs of electricity and natural gas, respectively, by local utility rates

Air Pollution Emission Reduction

Practices that indirectly lower emissions of air pollution include any practices that reduce energy consumption through decreased energy use in neighboring buildings or through reduced water treatment needs.

Figure 6: Air Pollution Emission Reduction

The kilowatt hours (or million BTUs) of reduced energy from the energy cost savings will be used in calculating the air pollution emission reduction benefit. The total amount of energy saved will be converted to the pounds of criteria pollutants reduced. The values, in dollars per pound, of the pollutants will come from existing guidance from the EPA and other sources that value these pollutants.

The EPA provides estimates for annual output emissions rates of national electricity production and natural gas:

Table 20: Sample Criteria Pollutant Emission Factors

Pollutant	lbs/kWh	lbs/Million Btu
NO2	0.001937	0.721
SO2	0.005259	0.266

Table 21: Costs of Pollutants

Pollutant	Value per lb
NO2	$3.34
O3	$3.34
SO2	$2.06
PM-10	$2.84

Source: CNT (2010), McPherson et al. (2006), Wang and Santini (1995)

Greenhouse Gas Emission Reduction

This benefit calculation follows the same methodology as the air pollution emission reduction benefit, only different conversion factors for CO2 will be used, and different monetary values.

The amount of CO2 emissions from power plants varies depending on the electricity source (e.g. coal, nuclear, wind, etc), so the EPA eGRID program should be consulted.

The CAMX subregion for 2010 has 932.82 lb per M Wh[21].

The current recommended price of CO2 is $40 per metric ton[22].

Figure 7: Greenhouse Gas Emission Reduction

[21] http://www.epa.gov/cleanenergy/energy-resources/egrid/

[22] Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013; revised November 2013), page 18

Air Particle Entrainment

This section quantifies the direct uptake and deposition of air pollutants by green infrastructure and provides a framework for establishing value these impacts in monetary terms. The criteria pollutants addressed here are nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter of aerodynamic diameter of ten micrometers or fewer (PM-10).

Figure 8: Air Particle Entrainment

Practices that provide a direct benefit of uptake and deposition include green roofs, trees and bio-infiltration. Similar to the methodology for emission cost savings from reduced energy use, the air particle entrainment benefits will quantify the amount (in pounds) of criteria pollutants removed from the environment. The total amount will depend on the scale of LID/GI and the type of GI. Table 22 provides values compiled by CNT (2010) per square foot of green roof installed. It should be noted that local values should be used if available (CNT, 2010). Factors such as local climates will influence plants ability to grow, and climates with longer growing seasons will see greater air quality improvements than those with shorter ones. Additionally, trees provide benefits in a similar manner. The Forest Service *Tree Guides* provides information for trees for particular climate regions (Table 23).

Table 22: Pollutant Removal Factors for Green Roofs

	Low (lbs/SF)	High (lbs/SF)
NO2	$3.00x10^{-4}$	$4.77x10^{-4}$
O3	$5.88x10^{-4}$	$9.20x10^{-4}$
SO2	$2.29x10^{-4}$	$4.06x10^{-4}$
PM-10	1.14x10-4	1.33x10-4

Table 23: Annual Criteria Pollutant Reductions, 40 year Average

	Small tree: Crabapple (22 ft tall, 21 ft spread)	Medium tree: Red Oak (40 ft tall, 27 ft spread)	Large tree: Hackberry (47 ft tall, 37 ft spread)
NO2	0.39 lbs	0.63 lbs	1.11 lbs
SO2	0.23 lbs	0.42 lbs	0.69 lbs
O3	0.15 lbs	0.2 lbs	0.28 lbs
PM-10	0.17 lbs	0.26 lbs	0.35 lbs

Carbon Sequestration

Similar to the air particle entrainment methodology, LID/GI can provide carbon sequestration benefits. The pounds of carbon sequestered per unit area depend on several local factors, including the specific practice, the types of species planted and the local climate.

For green roofs, the recommended range of grams of carbon sequestered per square meter from aboveground biomass, as determined by research synthesized in a Michigan State University report offers average carbon sequestration values provided by extensive green roofs' aboveground biomass (Getter et al. 2009).

Figure 9: Carbon Sequestration

Table 24: Green Roof Carbon Sequestration Rates

	Low (lbs/SF)	High (lbs/SF)
CO2	0.0332	0.0344

Table 25: Sample Carbon Sequestration Rates for Different Trees

Net CO2 (lbs)	Residential Yard Opposite West-Facing Wall	Residential Yard Opposite South-Facing Wall	Residential Yard Opposite East-Facing Wall	Public Tree on a Street or in a Park
Small tree: Crabapple (22 ft tall, 21 ft spread)	390	226	335	336
Medium tree: Red Oak (40 ft tall, 27 ft spread)	594	212	487	444
Large tree: Hackberry (47 ft tall, 37 ft spread)	911	665	806	735

Aesthetic Improvements

The current method to calculate the benefit of aesthetics is to look at the changes in property values due to LID/GI. While the research on this subject supports the belief that there is a positive (increase) in property value due to LID/GI, there is much uncertainty regarding the size and scale of that. The methodology for calculating this benefit is to apply a premium on property that will capitalize on the aesthetic benefits of LID/GI.

Street trees and urban vegetation have been estimated by realtors to add $15,000 to $25,000 in value to a property compared to similar areas with o trees. The NRDC notes that buildings with green roofs can rent at a 16% premium.[23] Additionally, the NRDC reports that Tyrväinen and Miettinen (2000) found that units in multifamily buildings with views of trees or forest cover can increase rents by as much as 4.9 percent (Wolf 2007)[24].

Figure 10: Aesthetic Improvements

Table 26: Premiums on Property Value due to Aesthetics

Action	Monetized Benefit	Location	Source
LID and proximity to trees and other vegetation	0 to 7% Increase in Property Value	Philadelphia, PA	Stratus 2009
LID of adjacent properties	3.5 to 5% Increase in Property Value	King County, WA	Ward et al. 2008

[23] Natural Resources Defense Council 2013

[24] Ibid

Recreation Benefits

Figure 11: Recreation Benefits

The methodology for calculating this benefit will involve determining the total number of recreational users of the new LID/GI facilities and applying a monetary value per user to get total benefits.

The total number of users will be based on local information. The monetized value of recreational benefits comes from different research fields. Some research from the transportation literature suggests benefits can be determined on an individual user basis. A wide variety of studies of outdoor recreational activities (non-bicycling) generated typical values of about $40 per day (in 2004 dollars).[25]

The value of time is estimated based on US DOT guidance for TIGER VI. The value of time for personal travel is $12.98 per hour. The benefit per trip for the appropriate facility is multiplied by the number of daily existing and induced commuters, and then doubled to include trips both to and from work. This results in a daily mobility benefit.

A premium on the value of a trip is developed from the January 2010 UK's Department of Transport *Guidance on the Appraisal of Walking and Cycling Schemes*. This Guidance reports a premium value of an off-road bicycle track versus an on-road facility. Hopkinson & Wardman (1996) developed estimates of on-road segregated cycle lane assuming benefits of £0.02 per minute. This benefit is assigned to existing recreational cyclists that would enjoy the new bike facility's quality, comfort and convenience.

Crime Reduction Benefits

Residents living in "greener" surroundings report lower levels of fear, fewer incivilities, and less aggressive and violent behavior. While there is not literature with respect to

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[25] San Francisco County Transportation Authority Department of Parking and Traffic. *Maintain Bicycle Facilities (spreadsheet)*. 2004 2/28/2004, as cited in *Guidelines for Analyzing the Benefits and Costs of Bicycle Facilities*, Krizek et al., 2005.

monetizing this benefit, there is research that looks at quantifying the benefit of crime reduction do to a greener environment. This study was performed in a public housing complex in an urban environment, so the actual percentage reduction may not be the same in other areas.

However, that does not mean there is no impact on crime. A possible methodology is to look at current crime levels in areas where proposed LID/GI will occur, and apply a reduction, but smaller in size than those listed below.

	Areas with Medium Level of Vegetation	Areas with High Levels of Vegetation
Total Crimes	42%	52%
Property Crimes	40%	48%
Violent Crimes	44%	56%

Source: Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Kuo & Sullivan. Environment and Behavior, Volume 33 No.3, May, 2001

Business Development Benefits

In areas where green streets lead to an enhanced the sense of place, and increase in foot and bicycle traffic can support retail development. Case studies by the New York City DOT examined before and after changes in Retail Sales Tax Filings, Commercial Leases & Rents, and City−Assessed Market Value. The study's methodology does not ultimately prove causality between the street improvement projects and any resulting economic changes; however, some locations of green street development saw a significant increase in retail sales compared to the changes in retail sales for the borough as a whole.

Researchers do believe that any benefits from the green streets will be fully realized 2 years after development, and so applying this growth to retail sales further in the future is not applicable.

We can apply these percentages to current retail sales of businesses located along areas that will be developed into green streets to see the potential impact on businesses.

Table 27: Increase in Retail Sales after Street Development

Area	Change in Sales Year 1	Change in Sales Year 2
Vanderbilt Ave	39%	59%
Borough	27%	19%
Area	**Change in Sales Year 1**	**Change in Sales Year 2**
St. Nicholas Avenue/Amsterdam	18%	48%
Borough	17%	39%

Job Creation Benefits

Determining the number of jobs created, and the economic impact of those jobs, is simply a function of the total amount spent on the program. In general, the larger the area (or economic base) the larger the impact. Direct, indirect and induced economic impacts from spending on the strategies can be calculated using Economic Impact Analysis models.

The creation of jobs, and such, salaries for the workers to spend, would also have tax impacts at the State, Local, and Federal government level.

Current guidance on a methodology from the Council of Economic Advisors' [26] methodology as assumes that for every **$76,923** of additional government spending, one job-year is created. A job-year means one job for one year. To estimate the employment impacts in terms of job-years one simply adds up the number of jobs created every year over the analysis period.

The number of jobs created is a division of the total spending by the CEA recommended value.

[26] Executive Office of the President, Council of Economic Advisers, "Estimates of Job Creation from the American Recovery and Reinvestment Act of 2009," Washington, D.C., May 11, 2009; and September 2011 Update.

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Appendix 2: Comprehensive List of Nonstructural Strategies

This list of strategies has been compiled from a review of each WAMP, CLRP and WQIP document

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
Jurisdictional Runoff Management Program (JRMP) Strategies			
Development Planning			
All Development Projects			
1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement low-impact development (LID) BMPs to maintain or restore hydrology of the area, where applicable and feasible.	For all development projects, ensure source control BMPs	Increasing # of BMPs or LIDs
2	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities.	Amend municipal code to encourage LID	Increasing # of BMPs or LIDs
3	Train staff on LID regulatory changes and LID Design Manual.	Train staff on LID regulatory changes and LID Design Manual.	Increasing # of BMPs or LIDs
Priority Development Projects (PDPs)			
4	For PDPs, administer a program requiring implementation of on-site structural BMPs or LIDs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs or LIDs.	For PDPs, require implementation of on-site structural BMPs or LIDs	Increasing # of BMPs or LIDs
5	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs or LIDs.	Update BMP Design Manual procedures	Improve / Maintain BMPs or LIDs
	1. Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.		Improve / Maintain BMPs or LIDs
	2. Amend BMP Design Manual for animal-related facilities.		Improve / Maintain BMPs or LIDs
	3. Amend BMP Design Manual for nurseries and garden centers.		Improve / Maintain BMPs or LIDs
	4. Amend BMP Design Manual for auto-related uses.		Improve / Maintain BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
6	Administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects).	Administer an alternative compliance program	Improve / Maintain BMPs or LIDs
	1. Develop a mitigation policy for public and private development projects that links development with mitigation within the same watershed.		Improve / Maintain BMPs or LIDs
	1a. Create an In-Lieu Fee		Improve / Maintain BMPs or LIDs
	Construction Management		
7	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Oversee implementation of BMPs during the construction	Improve / Maintain BMPs or LIDs
Existing Development			
	Commercial, Industrial, Municipal, and Residential Facilities and Areas		
8	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspecting existing development at appropriate frequencies and using appropriate methods. (Inspections for PGAs of concern: Vehicle Washing area inspections and inspections for food-related businesses, animal-related businesses, nurseries and garden centers, and auto-related businesses.)	Require implementation of minimum BMPs for existing development	Improve / Maintain BMPs or LIDs
	1. Update minimum BMPs for existing residential, commercial, and industrial development and enforce them.		Improve / Maintain BMPs or LIDs
	2. Design, implement, and enforce property- and PGA-based inspections.		Improve / Maintain BMPs or LIDs
	1. Review policies and procedures to ensure discharges from swimming pools meet permit requirements.		Improve / Maintain BMPs or LIDs
	3. Develop a self-reporting inspection option for select industrial and commercial facilities.		Improve / Maintain BMPs or LIDs
9	Implement pet waste program. May include installation and maintenance of pet waste bag dispensers and trash bins, signage and education, physical removal of pet waste, or enforcement.	Implement pet waste program	Changing Behavior to reduce pollutants at the source
10	Promote and encourage implementing designated BMPs at residential areas.	Promote and encourage implementing designated BMPs at residential areas.	Increasing # of BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	1. Expand residential BMP (irrigation, rainwater harvesting, and turf conversion) rebate programs to multi-family housing in target areas.		Increasing # of BMPs or LIDs
	2. Residential BMP: Rain Barrel		Increasing # of BMPs or LIDs
	3. Residential BMP: Irrigation Control (Turf Conversion)		Increasing # of BMPs or LIDs
	4. Residential BMP: Downspout Disconnect		Increasing # of BMPs or LIDs
	5. Provide financial incentives to property owners to convert landscaping to site-specific native plants.		Increasing # of BMPs or LIDs
11	Develop pilot project to identify and carry out site disconnections in targeted areas.	Develop pilot project to identify and carry out site disconnections in targeted areas.	Increasing # of BMPs or LIDs
12	Identify and reduce incidents of power washing discharges from nonresidential sites.	Identify and reduce incidents of power washing discharges from nonresidential sites.	Changing Behavior to reduce pollutants at the source
13	Promote and encourage implementation of designated BMPs in nonresidential areas.	Promote and encourage implementation of designated BMPs in nonresidential areas.	Increasing # of BMPs or LIDs
14	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	Monitor for erosion, and slope stabilization on municipal property.	Increasing # of BMPs or LIDs
MS4 Infrastructure			
15	Implement operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Implement operation and maintenance activities	Removing pollutants or sources directly
	1. Optimize catch basin cleaning to maximize pollutant removal.		Removing pollutants or sources directly
	2. Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.		Removing pollutants or sources directly
	3. Increase frequency of open-channel cleaning and scour pond repair to reduce pollutant loads.		Removing pollutants or sources directly

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
16	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	Implement controls to prevent infiltration of sewage into the MS4	Removing pollutants or sources directly
	1. Identify sewer leaks and areas for sewer pipe replacement prioritization.		Removing pollutants or sources directly
	Roads, Streets, and Parking Lots		
17	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Implement operation and maintenance activities for public streets	Removing pollutants or sources directly
	1. Enhance street sweeping through equipment replacement and route optimization.		Removing pollutants or sources directly
	2. Initiate sweeping of medians on high-volume arterial roadways.		Removing pollutants or sources directly
	3. Increase maintenance on access roads and trails.		Removing pollutants or sources directly
18	Require sweeping and maintenance of private roads and parking lots in targeted areas.	Require sweeping and maintenance of private roads and parking lots in targeted areas.	Removing pollutants or sources directly
19	Identify sites for pilot study to test Permeable Friction Course (PFC), which is a porous asphalt that overlays impermeable asphalt.	Identify sites for pilot study to test Permeable Friction Course (PFC)	Increasing # of BMPs or LIDs
	Pesticide, Herbicides, and Fertilizer Program		
20	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Require BMPs to address pesticides, herbicides, and fertilizers issues	Changing Behavior to reduce pollutants at the source
	Retrofit and Rehabilitation in Areas of Existing Development		
21	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Identify candidate areas for retrofitting projects	Increasing # of BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
22	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Identify areas for stream, channel, or habitat rehabilitation projects	Increasing # of BMPs or LIDs
IDDE Program			
23	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMPs. Requirements include maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for publicly reporting illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program	Changing Behavior to reduce pollutants at the source
Public Education and Participation			
24	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce pollutant discharge in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Implement a public education and participation program	Changing Behavior to reduce pollutants at the source
	1. Expand outreach to homeowners' association (HOA) common lands and HOA rebates.		Changing Behavior to reduce pollutants at the source
	2. Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.		Changing Behavior to reduce pollutants at the source
	3. Conduct trash cleanups through community-based organizations involving target audiences.		Changing Behavior to reduce pollutants at the source
	4. Target human behavior in parks and other public areas including trash reduction or other high-impact behavior to habitat, wildlife, and water quality.		Changing Behavior to reduce pollutants at the source
	5. Improve consistency and content of websites to highlight enforceable conditions and reporting methods.		Changing Behavior to reduce pollutants at the source

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	6. Contribute to San Diego County-led effort through regional education group for outreach, education, and policy measures for the equestrian community and property owners.		Changing Behavior to reduce pollutants at the source
	1. Develop a targeted education and outreach program for homeowners adjacent to or with tributaries or streams within their property.		Changing Behavior to reduce pollutants at the source
	1. Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.		Changing Behavior to reduce pollutants at the source
	2. Enhance school and recreation-based education and outreach		Changing Behavior to reduce pollutants at the source
	3. Develop education and outreach to reduce over-irrigation		Changing Behavior to reduce pollutants at the source
	7. Develop regional training for water-using mobile businesses.		Changing Behavior to reduce pollutants at the source
25	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	Enhance education and outreach	Changing Behavior to reduce pollutants at the source
26	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Technical education and outreach on the MS4 Permit and WQIP	Changing Behavior to reduce pollutants at the source
	Enforcement Response Plan		
27	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Implement escalating enforcement responses to compel compliance	Changing Behavior to reduce pollutants at the source

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	1. Increase enforcement of over-irrigation.		Changing Behavior to reduce pollutants at the source
	2. Focus locally on enforcement of water-using mobile businesses.		Changing Behavior to reduce pollutants at the source
28	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	Enforcement of actionable erosion and slope stabilization issues	Increasing # of BMPs or LIDs
Optional Strategies			
29	Continue participating in source reduction initiatives. (Varies. For example, the Brake Pad Partnership is existing. Considered may be a plastic bag ban, banning leaf blowers, banning pesticides or herbicide.)	Continue participating in source reduction initiatives.	Changing Behavior to reduce pollutants at the source
30	Develop a program to address and capture trash and debris.	Develop a program to address and capture trash and debris.	Removing pollutants or sources directly
31	Support partnership efforts by social service providers to provide sanitation and trash management for persons experiencing homelessness.	Sanitation and trash management for persons experiencing homelessness.	Removing pollutants or sources directly
32	Protect areas that are functioning naturally.	Protect areas that are functioning naturally.	Removing pollutants or sources directly
	1. Develop a policy to avoid additional hardscape development and degradation in unpaved open space areas.		Removing pollutants or sources directly
	2. Add permanent open space protections to undeveloped city-owned land.		Removing pollutants or sources directly
	3. Acquire privately owned undeveloped parcels of land.		Removing pollutants or sources directly
	Mapping and risk assessment of agricultural operations.		Removing pollutants or sources directly

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	Implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.		Removing pollutants or sources directly
	Removal of invasive plants and animals.		Removing pollutants or sources directly
33	Conduct a feasibility study to determine if implementing an urban tree canopy (UTC) program would benefit water quality and other goals.	Conduct a feasibility study on urban tree canopy (UTC) program	Increasing # of BMPs or LIDs
	Investigate alternative pollutant removal or treatment strategies such as fungus used to remove soil contaminants.		Removing pollutants or sources directly
34	Conduct special studies to gather additional monitoring information about priority conditions or beneficial uses. (Monitoring may include investigative measures such as genetic tracking for bacteria sources or geomorphic studies for sediment sources or processes. - LOS PEN)	Gather monitoring information about priority conditions or beneficial uses	Improve / Maintain BMPs or LIDs
35	Collaborate with entities potentially including, but not limited to:	Collaborate with entities potentially including, but not limited to:	Improve / Maintain BMPs or LIDs
	• Departments within the same Responsible Agency.		Improve / Maintain BMPs or LIDs
	• Other governmental agencies such as water, transportation, or public health agencies.		Improve / Maintain BMPs or LIDs
	• Nongovernmental agencies such as environmental and community groups and private corporations.		Improve / Maintain BMPs or LIDs
	• Dischargers regulated under other permits including the Phase II National Pollutant Discharge Elimination System (NPDES) Permit, Industrial General Permit, and Construction General Permit.		Improve / Maintain BMPs or LIDs
	Collaboration may take the form of joint participation in stakeholder meetings, studies or development studies or BMPs, hiring of a Watershed Coordinator to facilitate communication between community groups and the City, formation of a City Watershed team to protect and restore the watershed, or participating in existing groups, such as Integrated Regional Water Management (IRWM) groups.		Improve / Maintain BMPs or LIDs
	1. Funding for collaborative strategies may include providing in-kind services, shared costs through agreements, and preparation and competition for grant funding.		Improve / Maintain BMPs or LIDs

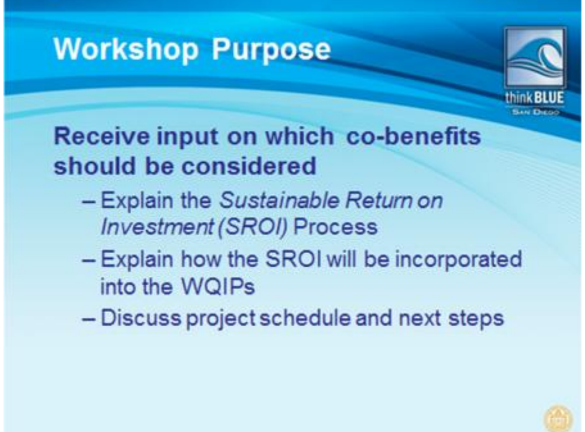
ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	Added		
	Vehicle Washing areas supplemental standards		Improve / Maintain BMPs or LIDs
	Keeping of large animals		Improve / Maintain BMPs or LIDs
	Xeriscaping, turf conversion and other irrigation, pesticide and fertilizer reduction (Caltrans specific. CLRP P. E-19)		Changing Behavior to reduce pollutants at the source
	Garden and landscape practices (primarily for Contractors. Otherwise covered in W.)		Changing Behavior to reduce pollutants at the source
	Increase street sweeping frequency (otherwise covered in P.)		Improve / Maintain BMPs or LIDs
	Rebates/Incentives to residential and non-residential. (Otherwise covered in J.)		Improve / Maintain BMPs or LIDs

Notes: Purple highlighting where there was a modification between the "Potential Strategies" documents.

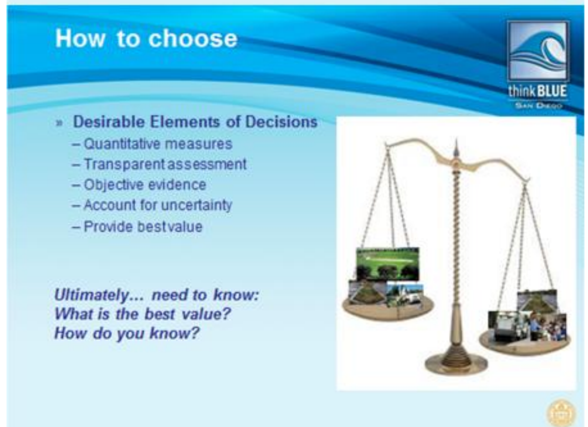
Appendix 3: Workshop Summary

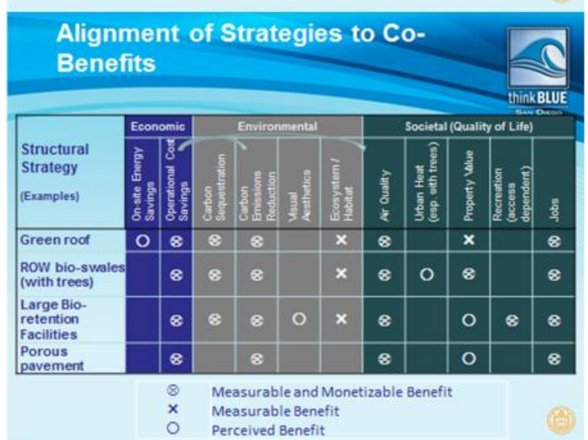
This section includes the presentation provided to the stakeholders, which guided discussion on benefits. Stakeholder comments were written down post workshop and sent back to the Division for consideration. These comments are included below.

Workshop Presentation



May 20, 2014	Co-benefit Workshop
May 27, 2014	Comments on Co-benefits Due
June - August 2014	Preliminary SROI Analysis
Late August, 2014 (tentative)	SROI Workshop Review
September, 2014	Finalize Analysis
Late September 2014	Potential Changes to WQIP Strategies (non-structural)





Structural Strategy (Examples)	Economic		Environmental				Societal (Quality of Life)				
	On-site Energy Savings	Operational Cost Savings	Carbon Sequestration	Carbon Emissions Reduction	Visual Aesthetics	Ecosystem / Habitat	Air Quality	Urban Heat (esp. with trees)	Property Value	Recreation (access dependent)	Jobs
Green roof	○	⊗	⊗	⊗		×	⊗		×		⊗
ROW bio-swales (with trees)		⊗	⊗	⊗		×	⊗	○	⊗		⊗
Large Bio-retention Facilities		⊗	⊗	⊗	○	×	⊗		○	⊗	⊗
Porous pavement		⊗		⊗			⊗		○		⊗

⊗ Measurable and Monetizable Benefit
× Measurable Benefit
○ Perceived Benefit

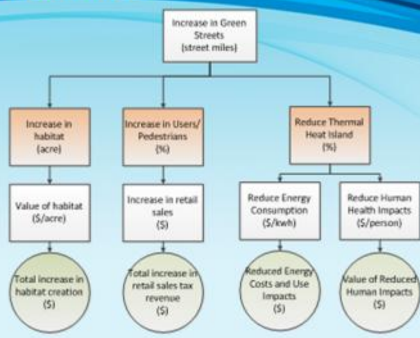
Potential Structural Strategies

- **Green Infrastructure**
  - Green streets, permeable pavement etc.
- **Multiuse Treatment Areas**
  - Infiltration and detention basins, stream rehabilitation, etc.
- **Water Quality Improvement**
  - Trash segregation, Proprietary BMPs, etc.

Co-Benefits of Green Streets

- **Unit of Measure**
  - Street miles of improvements
- **Drivers of Impact**
  - Water retained
  - Type of improvement (trees, etc.)
- **Key Co-Benefits**
  - Habitat creation
  - Business investment
  - Human health improvement
  - Energy Reduction

Green Streets Co-Benefit Calculations



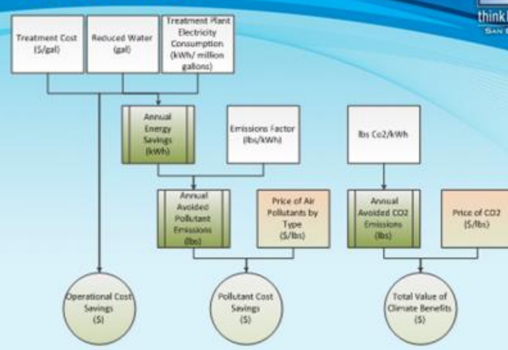
Potential Non-Structural Strategies

- **Increase # of structural systems**
  - Training, promotion, etc.
- **Improve structural systems performance**
  - Design codes, monitor, etc.
- **Initiatives to change behavior**
  - Education, enforcement, outreach, reduced pesticides, etc.
- **Initiatives to reduce pollutants directly**
  - Street sweeping, protect natural areas, etc.

Co-Benefits of Water Harvesting Strategy

- **Unit of Measure**
  - Reduction in stormwater runoff
- **Drivers of Impact**
  - Less water processed
- **Key Co-Benefits**
  - Reduced water consumption, less municipal water diversion
  - Reduced energy use and air pollution, GHG impacts

Water Harvesting Co-Benefit Calculations



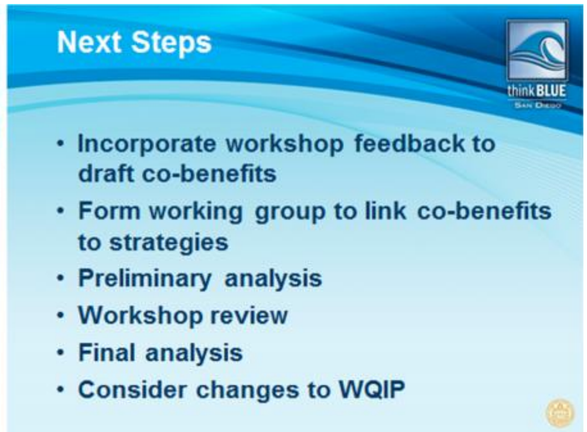
Co-Benefits of Education / Promotion of Think Blue Campaign

- **Unit of Measure**
  - # of people reached
- **Drivers of Impact**
  - # of people who reduce litter
- **Key Co-Benefits**
  - Improved residential neighborhoods aesthetics
  - Increase in business investment reduction in crime

Think Blue Program Co-Benefit Calculations (Partial)

- **Evidence**
  - Cleaner environments leads to decrease in crime
  - Urban housing with higher levels of vegetation and clean street showed decline in crime in nearby buildings


Breakout Session
think BLUE
San Diego
Property Owners
Aesthetics
Flood Control
Business Investment
Environmental
Green House Gas Reductions
Habitat Creation
Soil Stabilization
General Public
Recreational
Human Health
Stewardship
Heat Island
Air Quality
Crime Reduction
Operational Cost Savings
Jobs
Other
?


Next Steps
think BLUE
San Diego
• Incorporate workshop feedback to draft co-benefits
• Form working group to link co-benefits to strategies
• Preliminary analysis
• Workshop review
• Final analysis
• Consider changes to WQIP


Closing Remarks
think BLUE
San Diego
Questions?
Thanks for your participation!

Workshop Handout:

Water Quality Improvement Plans
Co-Benefits Description
Workbook

Co-Benefit: Aesthetics

Description: Visually appealing environments in communities, especially neighboring properties

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties, Proximity to BMP, % increase in Property Value

Unit of Value: $ increase per property

Comments:

Co-Benefit: Air Quality

Description: Reduction of pollutants which cause health impacts

Unit of Measure: Tons of Pollutant

Drivers of Value: Reduction in Energy Use, Increase in Absorbtion of Air Pollutants

Unit of Value: $ per ton of pollutant reduced

Comments:

Co-Benefit: Business Development

Description: Increase in investment and revenue in clean, walkable environments

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties,

Proximity to BMP, % pedestrian activity

Unit of Value: $ increase in retail sales

Comments:

Co-Benefit: Crime Reduction

Description: Clean/green neighborhods reduce incidents

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties,

Proximity to BMP, % decrease in crime incidents

Unit of Value: $ per incident reduced

Comments:

Co-Benefit: Environmental Stewardship

Description: Increased awareness and environmental responsibility

Unit of Measure: # of persons educated

Drivers of Value: Population

Unit of Value: # of persons educated

Comments:

Co-Benefit: Flood control

Description: Reduced flood risk

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: $ Cost per flood

Unit of Value: $ per flood damage reduced

Comments:

Co-Benefit: Green House Gas Reduction

Description: Reduction of CO2

Unit of Measure: Tons of CO2

Drivers of Value: Reduction in Energy Use, Increase in Carbon Sequestration

Unit of Value: $ per ton of CO2 reduced

Comments:

Co-Benefit: Habitat Creation

Description: Protection or Creation of habitats

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: Acres of urban habitat protected/create

Unit of Value: $ per reduced heat related illness

Comments:

Co-Benefit: Heat Island Reduction

Description: Reduced ambient temperatures

Unit of Measure: Area of BMPs

Drivers of Value: # of Reduced Heating Degrees Days

Unit of Value: $ benefits from reduction in health

Comments:

Co-Benefit: Jobs

Description: Increase in # of local jobs in installation and maintenance

Unit of Measure: Capital & Maintenance Expenditures

Drivers of Value: $ spent

Unit of Value: Number of jobs created

Comments:

Co-Benefit: Operational Savings

Description: Reduction in energy use to process water

Unit of Measure: Gallons of water reduced

Drivers of Value: Cost per gallon processed

Unit of Value: $ per gallon of Water Reduced

Comments:

Co-Benefit: Public Health

Description: Reduced exposure to pesticides and other chemicals

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, Ton of chemicals reduced

Unit of Value: $ per ton of chemicals reduced

Comments:

Co-Benefit: Recreation

Description: Increase in walkable environment

Unit of Measure: Size of recreational facility

Drivers of Value: Number of Recreational Users

Unit of Value: $ per recreational user

Comments:

Co-Benefit: Soil Stabilization

Description: Reduction in soil erosion

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: Acres of Stabilized Soil, Cost of Land Damage

Unit of Value: $ per acre of soil protect

Comments:

Workshop Comments Received

	Structural		
	Green Infrastructure (co-benefits)	Multi-Treatment Areas	Water Quality Improvements
1	Given that on the mesas, we have mostly clay soils that do not absorb storm water runoff, some of these potentials are limited. However, implementation of cisterns, vegetated filter strips, etc. have the potential to * Decrease flood risks as water is released into existing creeks over a longer period of time * Improve habitat as habitat is changing due to excessive water from urban run off (especially dry weather run off) * Dry water flow diversions will also reduce the excessive flows in many of our streams (compared to historical conditions)		
2	Topographic Blending of BMP/IMP approaches: upper watershed, mid, lower, coast Need to think beyond MS4 Parkways/sidewalks as filters, volume reduction, peakflow	Athletic Fields Parks - temp flooding,sedmiment capture	Micro - capture/treat; avoid regional systems Let habitat/green space do treatment
3	Comprehensive approach to improve water quality, reduce storm runoff and dry weather flows while providing education/outreach, as well as improving quality of life (improved feeling of “wellness”, reduction in health costs associated with polluted and/or stressful environments). Weight native landscapes (endemic to location) to give higher value than standard palette approach that uses species that excel in erosion control and/or coverage to meet landscaping sign off criteria as quickly as possible	Construct facilities (e.g. detention basins) that are specifically designed for the location versus “cookie-cutter” approach to design and implementation. Favor designs that can be passively converted back to native landscapes (e.g. basin becomes a wetland). Weight native landscapes (endemic to location) to give higher value than standard palette approach that uses species that excel in erosion control and/or coverage to meet landscaping sign off criteria as quickly as possible. Factor in maintenance needs (costs, access, mitigation, permits) and responsibilities into design and implementation. Consult with other divisions and departments within the City, as well as consultation with key stakeholder groups (neighboring communities, jurisdictions, NGOs that include	KEY CO-BENEFITS - Eliminating dry weather flows and reducing peak flows of storm runoff will provide a suite of co-benefits. Freshwater itself causes problems when inputs become perennial (e.g. habitat conversion, non-native species introduction and establishment, vector breeding habitat). More effective management and (hopeful) elimination of dry weather inputs could provide co-benefits by reducing the aforementioned impacts and assist in efforts to mitigate and, eventually, remediate them. Eliminating dry weather inputs will be needed for compliance for the Los Penasquitos Lagoon’s Sediment TMDL, since restoring salt marsh habitat within the lagoon in areas recently converted to brackish/freshwater habitat is one of the key compliance targets. Eliminating dry weather flows will also assist in compliance with the County-wide bacteria TMDL, since many “hot spots” are created or exacerbated by dry weather flows. Peak flows of storm runoff augmented by MS4 design or placement can create

	Structural		
	Green Infrastructure (co-benefits)	Multi-Treatment Areas	Water Quality Improvements
		non-profit management entities) to avoid conflicts in BMP implementation that include violation of NPDES permits, TMDLs, downstream impacts to receiving water bodies and valued habitats, creation of breeding habitat for harmful vectors, etc.	another suite of nasty things with regard to water quality that include loaded and delivery of contaminants to receiving water bodies, as well as contribute greatly to erosion and downstream sedimentation that create additional maintenance costs (e.g. digging out a box culvert or clearing sediment from a street) and can impact sensitive habitats that include receiving water bodies. Managing peak flows will also be needed to comply with the Lagoon's sediment TMDL, the county-wide bacteria TMDL, and load reductions for constitutes of concern and other harmful pollutants (e.g. pyrethroids) that cause impacts but have yet to be labeled "constituent of concern." Co-benefits of water quality improvements will need to consider improving the conditions of receiving water bodies (reduced bacteria loads, loss of functional habitats native to the region) rather than box checking to meet compliance targets (reduction of % of load by certain date, sending X amount of educational fliers out to communities). This will most likely involve consideration of qualitative data at some point, which should be captured some how (e.g. using it to weight criteria or alternatives under consideration. 10 Need to internalize costs associated with unintended and/or offsite consequences. For example - habitat conversion or creation of vector breeding habitat as a result of lowflow diversion that simply moves dry weather runoff somewhere else instead of addressing source(s) of the dry weather flows.
		Follow a comprehensive approach that considers benefits and impacts of both individual BMPs and a network of BMPs implemented throughout the watershed, including 9 receiving water body and valued habitats. Avoid knee-jerk reaction of putting out fires at specific locations. Rather, develop a comprehensive and adaptive approach that can be phased in over time to address water-quality priorities throughout their stages (shortterm, mid-term, long-term), take advantage of windows of opportunities (e.g. grant funding ops) and efficiently use available funding while setting up justification for future (and, when needed continuous) funding needs.	
4	Possible portable water purification systems that operates on solar/wind energy	Treat the water before it enters the main body of water (canal, creek, river, lagoon, bay, ocean) by means of detention ponds, catch basins, vaults, diversion systems, sump wells, or any underground storage unit.	Removing bacteria and metals that are associated with trash and run-off.
5			

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
1	Stream and/or habitat rehabiliation projects will increase biological diversity and provide more nature in our neighborhoods. Multi-treatment areas when focused on habitat restoration will enhance recreational opportunities, improve air quality, enhance aesthetics, contribute to heat island reduction, create jobs for upkeep and maintenance and providing living laboratories for our children to take their classroom learning into the field.		Initiatives to educate public and professional users of pesticides, herbicides and fertilizers will increase human health. Requiring interagency teams to deal with issues of homelessness will increase public safety while at the same time reducing feces and other toxic substances in our water. Initiatives to encourage proper disposal of pet waste will increase human health Initiatives to more quickly remove trash from recreational areas to keep them out of surface water will also improve recreational experiences and increase human health by limiting the amount of food available to rodents and hence reduce the rat population. Insuring that trash containers are available in all areas will keep trash out of surface water and will also improve recreational experiences and increase human health by limiting the amount of food available to rodents and hence reduce the rat population.	

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
2	School Cirriculum, Incentives			
3	Improve or replace existing MS4 structures before building new ones when feasible (the City cannot maintain what it has now, let alone new structures) Hire additional staff to manage permits and contracts to third-parties hired to assist Storm Water Division. improve enforcement actions (e.g. controlling dry weather runoff that meets water quality criteria or circumvents MS4 (e.g. freshwater mounding) but still creates impacts to receiving waters, such as habitat conversion, invasive plant establishment, breeding habitat for disease transmitting vectors).	Design and implement monitoring programs that make sense (e.g. answers questions or generates useful data) rather than just following programmatic lines. Review and enforce third-party agreements (e.g. HOAs maintaining private BMPs). Provide incentives to landowners and businesses to comply with hydromod requirements in areas already developed (and exempt from hydromod regs)	Coordinate with other stakeholder groups (e.g. NGOs) to help promote efforts that provide co-benefits to local communities and clarify/modify resource regulation that does not apply or should not in certain cases where lines of evidence support the effort over the regulation. Promote and incentivize native landscapes and water re-use	Improve controls over dry weather flows to address freshwater mounding and seepage into the MS4 or open space areas. Remove City infrastructure (e.g. MS4, sewer lines, water lines) from sensitive lands (e.g. Los Peñasquitos Lagoon).
	Include lessons learned from case studies regarding design, implementation and maintenance. Use site specific design and implementation rather than cookie-cutter approach to BMP and private properties (e.g. Hansen Agregate). Re-locate businesses built and operating in the flood zone (e.g. Sorrento Valley) as a longterm solution that is more cost-effective than annual maintenance and lawsuits.			

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
4	Private properties, as mentioned by the participants of the meeting on May 20th. (My company has had the privilege or working with Barona Casino I Barona Creek Golf where we found that they recycle all or their water run-off including rain, pavement, parking structure, landscaping and irrigation, which they all filter into one pond system for treatment. In addition, they are in the process of building reservoirs.}	Retrofit new proprietary technologies into existing structures by enhancing performance, focusing on set goals of contaminants of concern as overseen by SDRWQCB, EPA, etc. (Quantum Ozone has retrofitted into an existing vault/Catch Detention System prior to entering into a State Park, into a County Flood Tunnel, and also into existing ponds/lakes/reservoirs. We are open to any county/city or private property that would be willing to co-venture on a pilot project.)	Research outside the box of standard set BMP guidelines, to more natural /innovative technologies that are not part of existing BMPs. For example, ozone is 3,125 times more powerful than chlorine, and the misconception of it being "harmful" is due to lack of education. When properly applied, ozone will not cause negative bi-products, as Quantum Ozone has proved by not producing one negative bi-product in 7 years. We are an ozone planet, constantly having 0.02 parts per million of ozone constantly around us naturally.	Ground level education and awareness to future generations (3rd grade on up) to have Environmental Stewardship as part of the school curriculum along with' history and math, so that the governments that they create in the future will have these ideas naturally implemented into city maintenance and daily living.
5				Strategy: Elimination, to the maximum extent possible, of toxic chemicals in the environment, including herbicides, pesticides, detergents, poisons, paints, and petrochemicals. Co-benefit: an urban ecosystem that supports, to the maximum extent possible, a functioning food web from micro organisms to invertebrates and vertebrates. Co-benefit: recreation and educational opportunities in the form of diverse and inter-dependent organisms to observe and study. Co--benefit: swimmable and fishable waters.

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